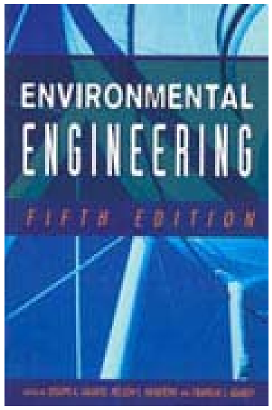
REGISTERED SANITARIAN

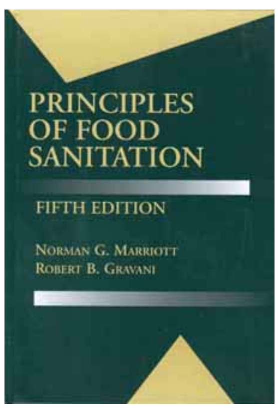
STUDY GUIDE

2007

Environmental Engineering (Hardcover)
by Joseph A. Salvato, Nelson L. Nemerow, Franklin J. Agardy



Principles of Food Sanitation (Food Science Texts Series)
by Norman G. Marriott, Robert B. Gravani



Study Guide for the Kentucky Registered Sanitarian Test

Environmental Engineering 5th Edition Edited by Salvato, Nemerow and Agardy

Chapter 1 Control of Communicable and Certain Non-Infectious Diseases

There is an abundance of information in this chapter that will be critical to your overall understanding of what the test will entail. Other chapters will not have such an in-depth review, because all of the information relates to other subject matter in the chapters that are recommended in this study guide, both in the Salvato text and the Marriott text.

Definitions Pg. 1-12

Of the eleven pages of definitions, be familiar with the following terms that are most related to Environmental Health

Antigen
Carrier
Communicable Disease
Disinfection
Endemic
Epidemic
Epidemiology
Host
Incubation period
Infectious disease
LD_{50}
NOEL
Pathogen
Personal Hygiene
Prospective study
Reservoir (of infectious agents)
Retrospective Study
Sanitize
Sterilization
Transmission of Infectious Agents

- a. Direct transmission
- b. Indirect transmission
    - (1) Vehicle borne
    - (2) Vector borne
        - (i) Mechanical
        - (ii) Biological
- c. Airborne

Infant mortality rate
Morbidity rate
Mortality rate

Disease Control Pg. 18, 23- to top of 32
Review information related to the following:

Core health problems in developing countries
Closely review Figure 1-1 on page 24 relating to Spread of Communicable Disease

a. Source
   (1) agent factors
   (2) examples of chemical, physical, and biological agent factors
   (3) how to control the source

b. Mode of Transmission
   (1) environmental factors
   (2) how to control the modes of transmission

c. Host susceptibility
   (1) animals and humans
   (2) dose
   (3) virulence
   (4) environmental pollutants
   (5) personal behavior
   (6) how to control host susceptibility

Typical Epidemic Control pg. 28-32

a. General Precautions During Outbreaks
b. General Sanitation

Respiratory Disease pg. 32-34

a. Koch's Postulates
b. Brief review of Table 1-6 Respiratory Diseases
c. Control Measures

Water and Foodborne Diseases pg. 34-38

a. Mode of transmission
b. General health effects
c. Conditions under which pathogens survive and die
   *Note: This information will be provided in the Marriott text also.
d. Generally know the dose necessary to cause illnesses such as Salmonella and Vibrio cholera compared to Campylobacter and Cryptosporidium.

Figure 1-2 Chart of Water and Foodborne Diseases pg. 40-48
Be familiar with the agent, reservoir, symptoms, incubation times, and preventive measures of the following waterborne and food borne diseases:

a. Botulism
b. Staphylococcus food poisoning
c. Clostridium perfringins
d. Bacillus cereus (emetic and diarrheal types)

e. Salmonellosis
f. Typhoid fever
g. Cholera
h. Campylobacter enteritis
i. Vibrio parahaemolyticus
j. Diarrhea enteropathogenic (Traveler's diarrhea)
k. Yersiniosis
l. Listeriosis
m. Vibrio vulnificus
n. Listeriosis

Study Guide Note: ALL DIEASES NOTED ABOVE ARE CAUSED BY BACTERIA, ALSO THESE DISEASES ARE DISCUSSED IN SIMILAR FASHION IN THE ESSNETIALS OF FOOD SANITATION BY MARRIOTT

Also, review the following waterborne/foodborne diseases caused by viruses and protozoa:

a. Hepatitis A
b. Viral gastroenteritis caused primarily by the Norwalk virus
c. Giardiasis
d. Cryptospordiosis
e. Trichinosis

Study Guide Note: KEEP IN MIND THAT ALL OF THE DISEASES ARE INCLUDED IN THE CONTEXT OF SPECIFIC SECTIONS OF SALVATO AND MARRIOTT TEXTBOOKS, HOWEVER THIS CHART MAY PROVIDE YOU WITH THE BEST APPROACH WHEN STUDYING FOR THE EXAM ONCE THE CHAPTERS HAVE BEEN READ THUOROUGHLY.

Historical Waterborne Disease Background pg. 55 to top of 57

Know common illnesses in Europe and the United States in the mid 1800s
Specific knowledge of the three classic al waterborne diseases of the time
Dr. John Snow
Robert Koch

General Knowledge of Waterborne Disease and Foodborne Disease Outbreaks and Control Measures. Read pg. to the top of 66.

Review Figure 1-3 Food Sanitation Temperature Chart pg. 66-

a. Temperature to kill Trichinella spiralis
b. Frozen food storage temperature
c. Recommended temperature for holding milk
d. Temperature range required for rapid bacterial growth
e. HTST pasteurization temperatures (actually 161 ^{o}F)

f. Batch and UHT pasteurization temperatures
g. Good dish sanitization temperatures

Other temperature parameters not illustrated include some specific temperature control requirements on page 68-72 in this chapter and page 1048 and 1049 in Chapter 8 on Food Protection.

Study Guide Note: THERE WILL BE MULTIPLE QUESTIONS RELATED TO THIS VERY IMPORTANT CONTROL MEASURE. THEREFORE, THIS IS A VERY IMPORTANT AREA TO REVIEW PRIOR TO TAKING THE EXAM

Carefully read and have knowledge of the definition of potentially hazardous foods according to the 2001 Food Code on page 73. It includes important information regarding the environment required for bacteria to survive and multiple in the list of exclusions

Insect borne Diseases and Zoonoses pg. 78-95

a. General information
b. Insect borne Diseases: Know reservoir, vector and control measure for the following which are organized in Table 1-13
   (1) Bubonic plague
   (2) Tularemia
   (3) Rocky Mountain Spotted Fever
   (4) Scabies'
   (5) Lyme Disease
   (6) Dengue Fever
   (7) Filariasis
   (8) Malaria
   (9) Yellow fever

   Also, know the following as discussed on pg. 84
   West Nile Virus
      Originated from the Middle East
      Spread by the Culex mosquito
      Flavivirus that causes encephalitis
      Cannot be transmitted person to person

c. Zoonoses: pg. 84-94
   (1) Tickborne diseases
   (2) Rodentborne diseases
   (3) Rabies
      (i) agent and rabid animals that transmit
      (ii) control measures
   (4) Anthrax, also known as woolsorter's disease from sheep, but also cattle, swine, and horses

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Chapter 3 Water Supply

Introduction pg. 255- to top of 259

a. Definition of a public water system
b. The number of public water supplies in the U.S. and people they serve
c. Global concerns regarding a safe and adequate supply of fresh water
d. Groundwater pollution concerns
e. Pollution effects in groundwater as opposed to surface water

Water Quantity and Quality pg. 265 to top of pgs. 268 and 271-317

a. Have a basic understanding of the Water cycle
b. Geological determinants of water quantity and quality
   (1) Igneous rocks
   (2) Sedimentary rocks
   (3) Metamorphic rocks
   (4) Karst areas
   (5) Porosity and Permeability
c. MCLs and MCLGs
e. National Primary Drinking Water Standards: Know the MCL for the following as listed in Table 3-4
   (1) Fluoride
   (2) Nitrate
   (3) Total coliform rule

f. Secondary Drinking Water Regulations: Know recommended level for the following as listed in Table 3-5
   (1) pH
   (2) Hardness
   (2) Iron

g. Coliform Testing Methodology and other tests pg. 289 (bottom) to pg. 297
   (1) Fecal coliform and Total coliform tests
   (2) Incubation temperature requirements
   (3) MTF technique
   (4) MF technique
   (5) PA Test and MUG Test

h. Know general information the health effects related to high levels of lead and nitrate in drinking water and control measures. Pg. 314-317.

Water Supply Provided by Groundwater pg. 338-373

About one-half of the U.S population is served by groundwater for drinking and domestic purposes. Agriculture is a major user of groundwater as is industry. The 1980 Census recorded that 33 million people are served by individual well-water systems. Others that do not have access to public water supplies may utilize a cistern, a pond or have their water delivered by water tank trucks. However the majority utilize the water-well to gain access to a potentially plentiful supply of groundwater. It is estimated that there is 20 to 30 times more water stored underground than in all the surface water streams and lakes combined. Gaining access to groundwater is easy. Protecting and developing source may be more difficult.

Have knowledge of the depth, diameter, possibility of contamination, quality and quantity of water in each of the following:

Types of wells:

a. Dug well
b. Bored well
c. Driven or jetted well
d. Drilled well

Spring:

a. Development
b. Protection
c. Infiltration Gallery

Cistern:

a. Water source
b. Quality and Quantity issues with cistern use
c. How much chlorine is to be used

Study Guide Note: THERE WILL BE A SUPPLEMENTAL CHAPTER IN THE APPENDIX WITH EXAMPLES OF POSSIBLE CALCULATIONS THAT MAY BE ON THE EXAM. ONE OF THESE IS TO CALCULATE HOW MUCH CHLORINE IS REQUIRED TO PROPERLY DISINFECT A CISTERN WITH KNOWN DIMENSIONS AND DEPTH OF WATER.

Well-Water Supplies- Know About These Special Problems and How to Treat Each:

a. Hard Water
b. Turbidity
c. Iron and manganese
d. Corrosion
e. Taste and Odor Problems

Study Guide for the Kentucky Registered Sanitarian Test

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Pipeline Publication on Wastewater Treatment and Supplemental Handout

<u>Chapter 4 Wastewater Treatment and Disposal</u>
There is general information regarding wastewater treatment in this chapter, but the sections on on-site wastewater treatment systems will be critical when studying for the test. In fact, the text does not give the detail necessary for your understanding the basics of on-site treatment of wastewater. Therefore, supplemental materials are also provided and outlined in this section of the study guide.

Common Enteric Pathogens found in Wastewater Pg. 535-537
Know how long they survive
Conditions necessary to survive
What level of removal of pathogens do steps in wastewater attain

Definitions Pg. 539-544
Of the four pages of definitions, be familiar with the following terms that are most commonly known to Registered Sanitarians

Aerobic bacteria
Anaerobic bacteria
Biochemical oxygen demand (BOD)
Chemical oxygen demand (COD)
Dissolved oxygen (DO)
Excreta
NPDES
Non-point pollution
Sewer
- -Combined
- -Sanitary

Stream Pollution and Recovery
BOD Test

a. Understand why the test is used and how BOD is derived, what conditions can be expected in a stream that has a low BOD as opposed to a high BOD
b. Be able to calculate BOD_5 Problem and BOD Loading Problem (See calculations supplement
c. Acceptable levels

COD Test

a. How it compares to the BOD test
b. When is it used

DO Test

a. Acceptable levels
b. For what purposes is the test utilized
c. What do low and high levels indicate and what are he effects

Eutrophication Pg. 549- 552

a. Explain the process
b. What kinds of water go through this stage
c. Review Table 4-2
d. What nutrients are associated with Eutrophication

Small Wastewater Disposal Systems Pg. 552- 600

Number of systems in the U.S.

The most common type system

Wastewater Characteristics

a. What is Black Water Examples
b. What is Gray Water Examples
c. What is in Wastewater

General Soil Characteristics

a. For reference purposes, soil is usually divided into gravel, sand, silt and clay
b. Read of how each of these are identified
c. Which ones are suitable and not suitable for small on-site wastewater systems
d. Know about Soil Structure, Restrictive Horizons, Landscape Position, Slope, Soil Texture, Soil Drainage, Soil Depth, as discussed in the text.
e. ***Also, be sure to carefully study the Soil/Site Evaluation Supplement attached. It will provide a good overview of the subject and will provide answers to more than six questions on the R.S. Exam***

Note: THERE WILL **BE NO QUESTIONS** ON PEROCLATION TESTS PAGE 562-566. ----SINCE THIS TEST IS NOT REQUIRED IN KENTUCKY AND EXPERIENCING DECREASED EMPHASIS IN OTHER STATES

Absorption Fields, also known as trenches, leach fields

a. How they work
b. Where can they be located and installed
c. Distances from wells, property lines, water service lines
d. The basic construction
e. The Biomat at the bottom of the trench
f. Size depends on number of bedrooms

Septic Tank

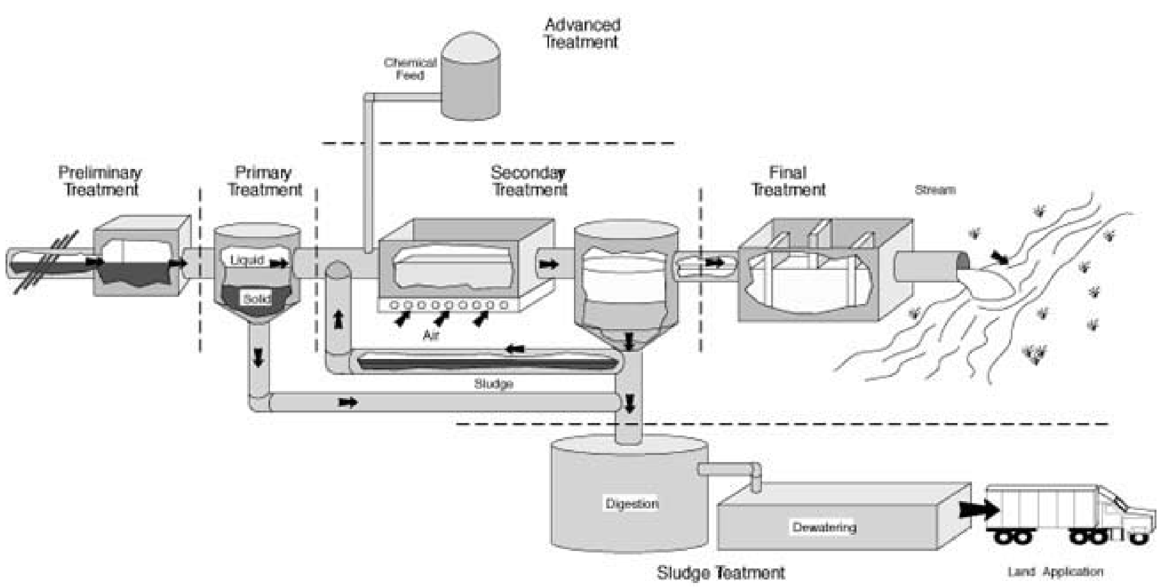
a. Its purpose
b. Sizing a septic tank to fit proper applications and sites
c. Recommended tank size
d. Detention time and implications if not properly attained
e. Review Figure 4-8 and 4-9

f. Suggested septic tank dimensions for the more common size tanks
g. How often should septic tanks be cleaned and who should do it
h. Materials septic tanks are constructed of
i. Read of the use of septic tank cleaners and additives
j. Why do septic tank systems generally fail

Sewage Works Design: Large Systems: Page 697 to Middle of Pg. 706 plus page 651-665 and 675-678
Wastewater Treatment Unit Processes

a. Primary Treatment (Physical Treatment by Gravity)
   1. Screening Racks
   2. Grit Chamber
   3. Comminutors
   4. Primary Sedimentation
b. Secondary Treatment (Biological Treatment) Options
   1. Trickling Filter
   2. Activated Sludge
   3. Land Treatment
   4. Stabilization Ponds (Lagoons)
c. Advanced (Tertiary) Treatment
   1. Denitrification
   2. Phosphorous Removal and other Examples

Figure 4-2 on page 699 is important to review, plus the schematic below may help. Know the sequence of the unit processes and a little about what is being accomplished at each step.



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Chapter 5 Solid Waste Management
This chapter will provide general information regarding solid and hazardous waste. It will be important to know the types of wastes generated, which types of wastes are on the decline and which ones are steady or increasing, the various waste management options, and the federal agencies and legislation regarding waste management.

Definitions: Page 756-759
Infectious waste
Hazardous waste
Sanitary Landfill
Solid waste

Integrated Waste Management (IWM)
Four basic options as identified by EPA
The IWM Hierarchy

a. Source Reductions
    1. What is the focus?
    2. Examples
    3. Cost internalization
b. Recycling
    1. Perception
    2. Problems associated with recycling
c. Combustion
    1. Advantages
    2. Major constraints
d. Landfilling
    1. Advantages over other options
    2. Aspects of a modern landfill Page 820-829

Sources, characteristics, quantities of residential & municipal solid waste. See Table 5-2

Commercial and Household Hazardous Waste
Contamination Aspects
Quantities Typically Generated
Typical examples of these kinds of hazardous waste
Medical Wastes

a. Federal Regulations
b. Examples of medical waste
c. Types of Wastes that are Exempted

Solid Waste Collection
Costs involved as an overall percentage of costs and direct costs of hauling
Collection frequency
Personnel Requirements and Health Issues
Finally, carefully read of the issues compost and constraints to its use beginning on pg. 806.

Hazardous Waste   Page 872-885
Four characteristics of hazardous waste
Kinds of waste not regulated under RCRA
Legislation:

- RCRA 1976
- RCRA 1984 Amendments
- CERCLA
- TSCA

Who are the major generators of hazardous waste?
Hazardous Waste Management

- The ultimate goal
- The options

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<u>Chapter 8 Food Protection</u> Page 1045, middle of 1048 to 1050 (very important section) Top section of 1052, Middle of 1058-1059, 1063-1064, 1068-middle of 1070, 1074-1075, 1084, 1097

Although the majority of questions on the Registered Sanitarian Exam related to food protection are taken from and review in the Marriott Text study guide, this chapter in Salvato includes important information not specifically discussed in that text. Please read and review the pages noted above. These pages will discuss the following subjects important to test preparation.

Food Handling and Temperature Control

Know minimum cooking temperature requirements eggs, fish, beef, poultry, pork, leftovers, stuffing…
Know hot holding temperature requirements
Serving prepared foods (temperature requirements)
Turkey thawing in refrigerator information
Cooling of bulk foods

Food Handler Examination and Responsibilities

Read this section carefully

Food Additives

The effects of Sulfites and Nitrites on food and health effects

Foodborne Pathogenic Organisms

Review information in this section with emphasis on C. botulinum

Ice

Potential for contamination
Bacterial Standards

Dry Food Storage

Recommendations for storage environmental conditions
Space requirements

Milk Quality

USDA Criteria
FSIS Inspections
Mastitis
Pasteurization
Temperature during storage, after milking…..

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<u>Chapter 9 Recreational Areas</u>

Information of swimming pools and other water recreation activities

Read page 1187 to middle of 1213, 1218 to middle of 1242

Health Considerations

Diseases potentially transmitted due to improperly operated pools, beaches, spas, hot tubs
Skin infections
Upper respiratory associated diseases
Incidence of outbreaks as reported by CDC
Source of these outbreaks
Particular problems with bathing beaches, hot tubs, spas and whirlpools

Regulations and Standards

Bathing beach water quality standards
Coliform levels in pools
Enterococci's role in determining incidence of gastroenteritis

Swimming Pool Water Quality

Proper pH, alkalinity, and clarity
Review Table 9-1

Sample Collection

At a pool
At the beach

Accident Prevention and Life Saving

Incidence of swimming pool injuries
Swimming pool drownings
- Type of pool most implicated
- Age groups most effected

Pool related Accidents
- Major types of injuries
- Primary Causes
- Preventive methods
  - Placement of diving boards
  - Number of trained guards recommended by Red Cross

Pool Design

Pool area and depth
Source of fresh water
Recirculation system (Note the Six Points under this heading and be sure to read the footnote regarding turnover rates)
Disinfection (Review only points 1, 2, and 3 under this heading)

Filtration
Overflow gutters and skimmers

Swimming Pool Operation
Water Quality
Routine tests performed
Disinfection; what are the options
Acceptable levels of pH, chlorine, bromine, calcium hardness in pool water

Control of pH
The effects of improper pH levels
Normal and recommended levels
What may cause a sudden increase or decrease in pH
How to increase pH to normal levels
How to lower pH to normal levels

Controlling Alkalinity
The effects of improper levels
Recommended levels
How to increase alkalinity to normal levels
How to lower alkalinity to normal levels

Iron and Manganese
Problems caused by increased levels
Quick test to determine presence of excessive levels

Algae
What leads to algae problems
How to control algae

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Chapter 10 Residential and Institutional Environment

Plumbing: Read Page 1340 to the Middle of 1364

By being able to define the following terms, the information conveyed for test purposes will be met:

- Air gap
- Back siphonage
- Cross connection
- Vacuum breaker

Indoor Air Pollution Read page 1350-1361

Biological contaminants

- Sources
- Examples of Respiratory diseases caused by indoor air biologics

Thermal and Moisture Requirements

- Recommended temperature levels
- Recommended humidity levels
- Problems associated with high humidity levels

Ventilation Read page 1361-1364

Acceptable minimum supply of fresh air per occupant

Standards for schools

Respiratory Illness Control

- NIOSH Suggestions

Institutional Sanitation Read page 1369-1384

Definitions:

Institution

Nosocomial infection

Hospitals and Nursing Homes

Incidence of hospital acquired infections

Examples of such infections

Reasons why hospital acquired infections occur

Preventive measures and recommendations

Hospital Related Waste

Types of wastes

% of waste that is considered infectious waste

Proper handling of infectious waste

Regulations and regulatory agencies involved

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<u>Chapter 11 Environmental Emergencies and Emergency Preparedness</u>
Read Pages 1393-1416. Also read and review the Beck Supplement to Salvato which is attached as an addendum to the study guide

Introduction:
Historical perspective of emergency planning
OSHA Involvement Early On
Hazard Communication Standard
- Common name
- Purpose
- MSDS Sheets

Know the primary purpose(s) of the following:
- EPCRA
- SARA
- HAZWOPER

What is the key to successful emergency preparedness

Emergency Operations Centers (EOC)
In an industrial setting
Proper location in an industrial or community
Who should be admitted
How should EOC be utilized
Power supply concerns and precautions
Sirens
PPE

Emergency Action Levels
Be able to identify/match descriptions of each action level and what each represents
Know the criteria and involvement for each Biosafety level (Found on pages 50 through 58 in the Beck Supplement to Salvato (Found in back of study guide)

Study Guide for the Kentucky Registered Sanitarian Test

Principles of Food Sanitation, 5th Edition by Paul Marriott and Robert Gravani, 2006

Chapter 1 Sanitation and the Food Industry

Reading Assignment: Page 1-11

There is general information regarding the complexity of the food industry, the agencies that monitor and enforce their activities and data regarding the size and complexity of the problems associated with Food Sanitation

Definitions

Sanitation
HACCP
Laws
Regulations
    Substantive
    Advisory
Adulterated Foods

Carefully Read and Have Knowledge of the Causes and Foods Implicated of Sample Foodborne Outbreaks on Page 5 and 6 Involving:

Salmonella enteriditis
E-coli 0157:H7
Listeria Monocytogenese

FDA Regulations

Have knowledge of:
Interstate Commerce
Misbranded and Adulterated Foods
U.S. Marshall's Assistance

USDA

Have knowledge of:
Federal Meat Inspection Act
Poultry Products Inspection Act
Egg Products Inspection Act
FSIS
Pathogen Reduction: HACCP Final Rule

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<u>Chapter 2 The Relationship of Biosecurity to Sanitation</u>
Reading Assignment: Page 16-24

This chapter reviews the importance of protecting our food supply from natural and intentional microbial, chemical, and physical contamination. Also, discussion of the Homeland Security Act and concerns we might have in this time of terroristic activity.

Key Issues to Study:

Knowledge and History of Bioterrorism in food processing and food preparation areas.

Possible Agents that may be used in terrorist attacks
- Hemorrhagic fever virus
- Ricin
- Botulinum toxin

Food Industry's Focus: Reference to the 3 P's
- Personnel
- Property
- Product

Bioterrorism Protection Measures
- FDA Interim Final Rules
- Bioterrorism Act

Collaboration Between Biosecurity and Pest Management
- Registration of Food and Animal Feed Facilities
    - Biosecurity Act Requirements
    - Define facilities
    - Exemptions

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Chapter 3 The Relationship of Microorganisms to Sanitation

Reading Assignment: Page 25 to the middle of Page 55 and Salvato as noted

There is an in-depth review of the effects of microorganisms on food causing spoilage, illness and in some cases being used positively to process certain foods, how contaminated foods can cause illness when ingested and how microorganisms grow and die.

Definitions

Microorganism
Foodborne illness
    Food Infection
    Food Intoxication
Pathogen
Bacteriostats and Bacterocides
D Value
Aerobic and Anaerobic bacteria (These are also defined in Salvato Chapter Reviews)
Biofilm
Foodborne Illness Outbreak

Microorganisms Common to Food

Most common to food are Bacteria and Fungi

Mold: (Multicellular)
    Conditions under which they grow
    Beneficial Molds and Molds that can cause illness
    How to Control Molds

Yeast: (Unicellular) Larger than Bacteria
    Generation of Yeasts
    Conditions under which yeasts grow
    How to Control Yeast

Viruses: (Not really a microorganism, but a single molecule of DNA or RNA in a protein wrapper.)
    Unlike the others, they cannot reproduce outside a living host and die much quicker in the environment
    Employees are carriers
    How are they transmitted to foods
    What foods are more likely to contain viruses
    Hepatitis A is the most common viral foodborne illness

Bacteria (Unicellular)

- Know morphology of bacteria
- Read about spore forming bacteria
- Bacterial Growth: What occurs during each of the following stages
  - Lag phase growth
  - Log phase growth
  - Stationary phases
  - Accelerated death phase

Factors Affecting Microbial Growth (Especially related to bacteria)

To begin, this new edition of Marriott has confused the issue to temperature control by using Celsius instead of Fahrenheit. Therefore, I will convert temperature parameters used in the section from page 30-34 for you here:

14 ^{0}C = 57.2 ^{0}F	20 ^{0}C = 68 ^{0}F	40 ^{0}C = 104 ^{0}F	45 ^{0}C = 113 ^{0}F
15.5 ^{0}C = 60 ^{0}F	3 ^{0}C = 37.4 ^{0}F	4 ^{0}C = 39.2 ^{0}F	

Factors

Temperature: The Food Code States that microbes grow best in the danger zone which is 41 ^{0}F to 140 ^{0}F. The perfect growth temperature for most bacteria is 98.6 ^{0}F which is human body temperature.

To avoid the danger zone, regulations require foods to be stored below 41 ^{0}F in a refrigerator until ready for preparation and be cooked to an internal temperature of 140 ^{0}F as soon as possible. There are exceptions to these rules discussed in Salvato Page 1049.

The minimum internal cooking temperature:
-For eggs, fish and beef is 145 ^{0}F
-For Poultry, Pork, and leftovers including stuffing is 165 ^{0}F
-Frozen meat and poultry should be thawed in a refrigerator at 40 ^{0}F *
-Prepared foods, especially protein types, should be served immediately, kept temporarily at a temperature of less than 40 ^{0}F or on a warming (steam) table maintaining a temperature of 140 ^{0}F or above until served

  * Note Table 8-1 on Turkey Thawing Time According to Size

Also, note the classification of Microbes According to Temperature

- Thermophiles
- Mesophiles
- Psychrotrophs

Know examples of each and temperatures in each classification

Oxygen Requirements: Some microorganisms require free oxygen and some thrive in non-oxygen environments, while others can survive in either. Know examples of each

Relative Humidity: Know how much humidity is necessary and how are microorganisms affected by RH. What problems can high humidity lead to and know it association to Water Activity A_w

pH: Yeasts can grow in an acidic environment, molds can grow in a wide pH range, while bacteria prefer a neutral pH of 7, but there are potentially hazardous foods that can survive and proliferate at ph levels of 4.6 and above.

Nutrient Requirements: Most microorganisms need external sources of nitrogen, carbohydrates, protein, or lipids. They get all of these from foods we call potentially hazardous foods such as; milk and milk products, eggs, poultry, meat, pork, seafood, shellfish…..but also other foods we as well.

Foodborne Illness

Page 35-52 is an important section on foodborne illness. Table 3-3 (Page 39-41) should be very helpful when reviewing for the test, but specific information is included within these pages that will also generate numerous test questions.

http://vm.cfsan.fda.gov/~mow/intro.html is a website that discusses all foodborne illnesses.

Suggestion: Make 3 by 5 cards on each of these foodborne illnesses noting foods implicated, signs of symptoms of illness, incubation time, prevalence and what populations are most affected. Also, note anecdotal information such as the foodborne illness caused by Yersinia enterocolitica mimics appendicitis. Also, it is one of the few foodborne illnesses that is psychrotrophic.

Apply these study parameters to the following foodborne illnesses found in the readings from page 35-52.

Bacillus cereus	Listeriosis
Botulism	Salmonellosis
Campylobacteriosis	Shigellosis
Clostridium perfingins	Staphylococcal Intoxication
E-coli 0157:H7	Yersiniosis

Also, know some general info. of Trichinosis, Enterotoxigenic e-coli, and Vibrio spp.

Microbial Destruction Page 53-55

This basic information has already been presented or will be included in other sections.

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Chapter 4 The Relationship of Allergens to Sanitation

Reading Assignment: Page 70-75

This is a short chapter addressing a problem of growing importance in the food processing industry. Industry sees this as an urgent problem that must be addressed and the public warned. Data included as the prevalence states that 30,000 emergency room visits and 200 deaths are attributed to food allergens each year with 2 to 3% of adults being affected and 4 to 8% of our children.

What You Should Know

How is industry addressing this problem?
What are the Eight Foods that most likely contain allergens?
What agencies are involved in addressing the problem and what are they doing?
What are allergens?
What is the natural human response that leads to a reaction?
What kinds of symptoms follow?
What are the causes of Allergen contamination?

Study Guide for the Kentucky Registered Sanitarian Test

Principles of Food Sanitation, 5th Edition by Paul Marriott and Robert Gravani, 2006

Chapter 5 Food Contamination Sources

Reading Assignment: Page 76-78

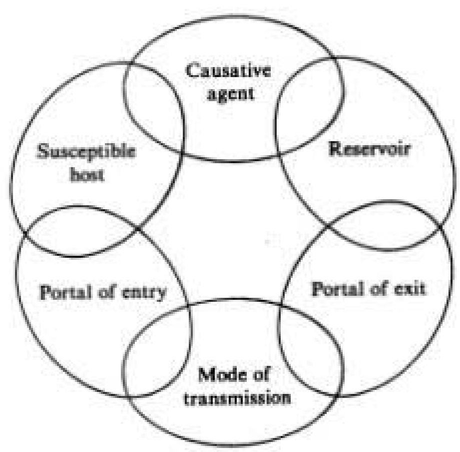
Primarily, this chapter is an overview of information that is presented in previous chapters and chapter yet to be reviewed. Pertinent information to review in this chapter includes:

Page 76- Cold Storage: Refrigeration is the most viable method of reducing the effects of contamination. Cooling rates are affected by container size with Clostridium perfringins (the cafeteria germ) used as an example.

Page 77- Chain of Infection which illustrates the events or factors that lead to an infection. Here is an example for Salmonellosis caused by undercooked chicken

Agent: Salmonella enteriditis
Reservoir: Intestinal Tract of Warm Blooded Animals
Portal of exit: Feces
Mode of Transmission: The undercooked poultry
Portal of Entry: Ingesting (eating the undercooked food)
Host Susceptibility: Those most susceptible to Salmonellosis are the elderly, the very young and those already immuno-compromised.

If the host is not susceptible or if the chicken had been cooked properly, Illness does not occur. Break any link in the chain and illness is prevented.



Page 78- Review Figure 5-2

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Chapter 6 Personal Hygiene and Sanitary Food Handling

Reading Assignment: Page 83-98

Humans are the most common source of food contamination. Hair, perspiration, dirty clothing, excessive jewelry, purses, coats, finger nail polish, long fingernails harboring bacteria, working around food while suffering from a communicable disease are just a few ways that humans contaminate foods with pathogenic bacteria.

Definitions

Hygiene
Personal hygiene
Carrier

Pathogens that food service workers tend to be carriers of include:

- Staphlycoccus aureus
- Salmonella
- Shigella
- Hepatitis A- May be a carrier for up to 5 years after becoming well.

The Importance of Handwashing

- Proper handwashing procedure
- How long should it take to wash hands properly
- Mechanical handwashing- How effective is it?
- Alcohol hand rubs, gels, or rinse sanitizers- How effective is it?
- Use of gloves- The controversy

Employee Personal Hygiene Risks

- Employee responsibilities
- What to look for during an employment interview to predict hygienic behavior

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<u>Chapter 7 The Role of HACCP in Sanitation</u>

Reading Assignment: Page 99-114

HACCP is a preventive approach to hygiene and safety. It has nothing to do with food quality, only those aspects related to potential health concerns. The keys to HACCP are prevention and documentation. A team determines how and where food safety hazards exists and set forth to address these critical control points.

Definitions

HACCP
Hazard
CCP

History of HACCP

Its Origin
What agencies and company were first involved in its implementation?
What was the reason for it earliest implementation?
Poultry and Seafood were the first industries to implement HACCP

The Focus of HACCP

Proper Temperature Controls
Particularly, improper cooling of hot foods
How HACCP differs from traditional inspectional programs in attaining sanitation goals
The benefits of HACCP
The first major pathogen targeted by HACCP
HACCP Principles- General Review Only

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Chapter 10 Sanitizers

Reading Assignment: Page 165-179 Up to Peroxy Acid Sanitizers

This is an in-depth review of the efficacy and properties of various sanitizers being used in food processing and the food service industry. Table 10-2 gives an excellent overview of the more common sanitizing options and when one is best used over another. Each sanitizing option has its own advantages and disadvantages. It would serve one well to be aware of these variances.

Definitions

Disinfectant
Sanitizer
Sterilize

Sanitizing Methods:

Thermal (Heat) Sanitizing
- Steam
- Hot Water

UV Radiation

Chemical Sanitizing: Efficacy is affected by the following physical factors
- Temperature   **
- Exposure Time   **
- Concentrations   **
- pH   **
- Equipment cleanliness
- Water hardness **
- Microbial population

Relate these physical factors (especially those noted **) to each of the following chemical sanitizers:
- Chlorine
- Iodine (Especially Idophors)
- Quaternary Ammonia
- Acid Sanitizers

Also, be aware of which sanitizers work best in hard water, which ones work best in destroying viruses, bacteria, yeasts, which ones are corrosive, etc.

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Chapter 13 Pest Control

Reading Assignment: Page235-255

This chapter discusses many of the pests that contaminate our food supply, potentially causing disease. In addition, these pests are very destructive costing the food industry billions of dollars annually. Although various control measures are discussed for each pest, keep in mind that good housekeeping is the first and best line of defense against these pests.

Cockroaches

The most common pest in the food industry worldwide
Potentially carry about 50 pathogens such as cholera, salmonella, and shigella
Spread these pathogens through contact with food
Prefer foods high in carbohydrates
Identifying the species of cockroach present aids in their control

Species of Cockroaches: ***For each, know their comparative sizes, how many roaches they produce per egg capsule and how often, and where they are found***

German cockroach
American cockroach
Oriental cockroach

Control Measures:

Effective Sanitation
Lighting in storage rooms and building exterior
Filling cracks in floors and walls with caulking
Eliminate small spaces between equipment
Use of pesticides as a last resort

- Diazanon- used as a residual sprayed in cracks and crevices
- Dursban- effective against roaches that developed resistance to other pesticides
- Pheromone traps
- IGRs (Insect growth regulators)

Flies

The most common seasonal insect in food service and food processing plants
Although there are numerous species of flies, the one species that presents a public health concern in the housefly (Musca domestica)
Pathogens carried by Housefly are numerous and include typhoid, staph, salmonella, dysentery.
They feed on animal and human waste
Life cycle of the Housefly
Know how they contaminate food
Control measures

Rodents

Both rats and mice are difficult to control because of their highly developed sense of smell, hearing and touch. Bait shyness is always a problem because they tend not to go near anything new in their surroundings, rats more so than mice.

Rats

Can enter through an opening the size of a quarter
Are good climbers, swimmers, and jump well
Are dangerous and destructive, potentially carrying every conceivable pathogen known and causing more than 10 billion dollars of damage to the food industry annually
Produce an average of 20 offspring per year
Species of Rats

- Norway Rat (Rattus norvegicus)- the most abundant and largest
  - Brown, 18-25 cm long, blunt nose and thick body

- Roof Rat (Rattus rattus)- found in south and along west coast. Nests are elevated
  - Black or Gray, 16.5-20 cm long

Mice

Can enter through an opening the size of a nickel
Are good swimmers, excellent sense of balance
Also potentially carry numerous pathogens
Produce an average of 30-35 offspring annually
Mice do not need a source of water to survive, metabolize their own from food
Enter food facilities generally in crates and cartons

How to Control Rodents:

Prevention of entry- know the various options noted in text
Elimination of shelter and food sources
Poisons, Gassing, Trapping, Ultrasonic devices

Note: Most of the information in the following chapters has been covered in previous readings, so focus on the following;

CHAPTER 16 DAIRY PROCESSING PLANT SANITATION
Read only "Role of Pathogens" in this chapter. Pg. 284-to top of 286

CHAPTER 21 FOODSERVICE SANITATION
Read only 371 to top of 373

Summer 2004
Vol. 15, No. 3

Pipeline

Small Community Wastewater Issues Explained to the Public

NESC

Septic Systems—A Practical Alternative for Small Communities

The septic system, once thought of as a temporary treatment for domestic wastewater until public sewerage could be obtained, is making great strides and holding strong in the industry today. With nearly one out of every four homes and one out of every three new housing starts in the U.S. relying on some form of septic system to treat and dispose of household wastewater, the concept of septic systems being a temporary treatment is no longer applicable.

When properly designed, installed, and maintained, septic systems can be the most cost-effective and efficient method of wastewater treatment and have a minimum life expectancy of 20 to 30 years.

Because septic systems treat and dispose of household wastewater onsite, they are often more economical than centralized sewer systems in rural areas where lot sizes are larger and houses are spaced widely apart.

By using natural processes to treat the wastewater onsite, usually in a homeowner's backyard, septic systems don't require the installation of miles of sewer lines, making them less disruptive to the environment.

The traditional septic system is simple in design, which makes it generally less expensive to install and maintain. Today, many innovative designs for septic systems allow them to be placed in areas with shallow soils or other site-related conditions previously considered to be unsuitable.

In spite of these facts, septic systems suffer from an image problem.

Septic systems have been in use since the turn of the century. Their use became widespread after World War II when the suburban housing boom outgrew the rate of sewer construction.

At that time, the biggest assumption was that they would ultimately be replaced by central sewers. Throughout the 1960s, the concept of septic tank systems being an undependable, old-fashioned, or temporary solution until a conventional sewer system could be built continued.

Part of the blame for the poor reputation of septic systems can be traced to the popularity of conventional sewer systems in the 1960s and early 1970s, when more government funding was available to install and maintain large, complex systems. These systems were planned for and designed to provide service over the plant's life expectancy of 20 years or more, which ironically is the same life expectancy of a conventional septic system.

Many communities weren't informed about possible alternatives and, therefore, didn't consider more cost-effective or appropriate decentralized technologies, like septic systems. And engineers, local officials, and community residents sometimes were easily impressed by more high-tech solutions to problems.

Please note that this issue of Pipeline is an update to the Spring, 1995 issue, Vol. 6, No. 2.

Pollution of local groundwater, lakes, and streams due to septic system failures is also responsible for their unpopularity in some communities. However, most of these failures can be attributed to old systems with poor design, maintenance, and installation, or

Advantages

- Simple and effective wastewater treatment
- Less disruptive to the environment to install and maintain
- Less expensive to operate than centralized treatment facilities
- Provide wastewater treatment in areas where it would not be available otherwise
- When functioning properly, can help replenish groundwater

Disadvantages

- Must be pumped routinely, usually once every three to five years
- Water use must be monitored to not overload the system
- Must use care not to dispose of chemicals or other toxic substances through your drains and toilets. (See Page 3.)

inadequate site evaluations before installation.

In the past, a lack of adequate regulations for septic system design, construction, and installation also contributed to septic system failures. With proper management and homeowner education programs, most problems with septic systems can be avoided.

As the population increases with urban sprawl, the need for properly managed, maintained and operated septic systems is paramount. The total volume of waste disposed of through septic systems is over one trillion gallons per year, according to a study conducted by the U.S. Environmental Protection Agency's Office of Technology Assessment, and virtually all of that waste is discharged directly to the subsurface, which affects groundwater quality.

This issue of *Pipeline* presents some basic information about septic tank systems, how they work, and where homeowners and community leaders can find further information and assistance.

Septic System Components

Septic systems are wastewater treatment systems that collect, treat, and dispose of wastewater generated by homes or businesses. The wastewater is treated onsite, rather than collected and transported to a centralized community wastewater treatment plant. (See Figure 1.)

There are several variations of the basic septic system design in use today. While many systems are individually designed or adapted for a specific site, most work using the same basic principles.

A septic system consists of two main parts; a septic tank and a soil absorption system (SAS), also known as a drainfield, leachfield, or disposal field. The entire system is connected by pipes, and a sewer pipe connects the home or business to the septic system.

The Septic Tank

The main function of the septic tank is to collect household wastewater, which includes water from the toilet, commonly referred to as blackwater, and water from the bathtub, showers, sinks, and laundry, which is known collectively as graywater. However, some states include kitchen sink waste as blackwater. The septic tank treats the wastewater naturally by holding it in the tank long enough for solids and liquids to separate.

Treatment begins when the household wastewater flows from the home to the septic tank through the sewer pipe. A baffle (an internal flap) or tee (a T-shaped pipe) at the inlet slows the flow of wastewater going into the tank and directs it downward toward the middle of the tank. The wastewater is then retained for a day or more in the tank to allow the solids in the wastewater to separate from the liquids.

Inside the tank, solids lighter than water—such as greases, oils, and sometimes, other solid materials like toilet paper—float to the top forming a layer of scum. Solids heavier than water settle at the bottom of the tank forming a layer of sludge. This leaves a middle layer of partially clarified wastewater. (See Figure 1a.)

An outlet baffle in the septic tank is positioned to allow only the partially treated liquid waste in the middle layer to flow out of the tank for further treatment.

The layers of scum and sludge remain in the septic tank where bacteria found naturally in the wastewater work to break the solids down. This process takes place anaerobically (without the presence of oxygen), and gases produced from the decaying solids are vented back through the sewer line and released, usually through a plumbing vent located on the roof of the house. The sludge and scum that cannot be broken down is retained in the tank until the tank is eventually pumped.

After the wastewater is allowed to settle and separate in the septic tank, the partially treated liquid from the middle layer flows through the outlet baffle or tee to the SAS.

Septic tanks are usually made of precast concrete, fiberglass, or plastic, and come in a variety of shapes and sizes. In order for septic tanks to work properly, they must be watertight and resistant to corrosion. For this reason, metal tanks are not recommended.

Most septic tanks are single-compartment tanks. Some people prefer tanks with two or more compartments because they feel settling ability may be enhanced. Multi-compartment tanks use the same process to treat the wastewater as single-compartment tanks. Some states recommend or require two or more compartments for septic tanks that hold 1,000 gallons or more, or two or more septic tanks used in series, one after the other, to provide additional treatment.

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To keep your septic tank and soil absorption system operating properly follow these general guidelines:

Do not flush or dispose of in the drain:

- Cloggers like diapers, cat litter, cigarette filters, coffee grinds, grease, condoms, feminine hygiene produce, dental floss, prescription or over-the-county medications, or scrap foods.
- Killers such as household chemicals, gasoline, oil, pesticides, antifreeze, paint, and paint thinners.

Septic tank filters, screen- or basket-like devices that trap and retain solids, are another way to enhance treatment inside septic tanks. (See figure 1b.) A relatively new technology, septic tank filters are included with some newer septic tank designs, or can be retrofitted to work with older designs. Homeowners should check with their local health departments to see if septic tank filters are required or recommended.

Septic tanks are usually rectangular, oval, or round. The overall shape of the septic tank has little to do with its performance, but tank size is a very important factor. Septic tanks must be large enough to accommodate the needs of the household.

The size of a septic tank is usually determined by the number of bedrooms (not bathrooms) in a home. One way to estimate the size of a septic tank necessary for an average household would be to multiply 150 gallons per bedroom per day, and then multiply this number by two to allow for two days retention time in the tank. Using this formula, a three-bedroom house would use 450 gallons of water per day, and would require at least a 900-gallon septic tank for two days retention. Standard septic tank sizes include 750, 1,000, 1,200, and 1,500 gallons.

While there are several formulas available for estimating septic tank size, it is most important for homeowners to know the specific regulations for septic tank size and design in their state or area.

Soil Absorption System

In a conventional septic system, the wastewater flows by gravity from the septic tank to the SAS or to a distribution device, which helps to uniformly distribute the wastewater flow in the drainfield.

The soil absorption field provides the final step in the wastewater treatment process. The size of a SAS is usually based upon the size of the house and percolation rate of the soil.

A standard field is a series of trenches or a bed lined with gravel or coarse sand and buried one to three feet below the ground surface. Perforated pipes or drain tiles run through the trenches to distribute the wastewater. (See Figure 1d.)

The drainfield treats the wastewater by allowing it to slowly trickle from the pipes out into the gravel and down through the soil. The gravel and soil in a drainfield act as biological filters.

As the wastewater percolates (moves through the soil) to the groundwater below, the filtration process and organisms in the soil work together to remove toxics, bacteria, viruses, and other pollutants from the wastewater. Soil particles, particularly clay, chemically attract and hold sewage nutrients, metals, and disease carrying organisms. This process can effectively treat the wastewater to an acceptable level that will not contaminate the groundwater. Therefore, it is very important that adequate separation exists between the bottom of the trench/bed and a limiting layer, such as groundwater or bedrock.

Certain toxics, such as paints, paint thinners, pesticides, waste oils, and other hazardous chemicals, cannot be treated by the drainfield and should never be disposed of through a septic system. Some of the chemicals also kill the bacteria found in the septic tank, temporarily disrupting the natural treatment process that occurs in the septic tank.

A thorough site evaluation should be conducted at the beginning of the planning stage. Septic system failures are often caused by poorly conducted evaluations or results of evaluations that did not occur at the beginning of the planning process.

Site Evaluation Is Essential

In a typical site evaluation, a sanitarian, engineer, or other wastewater professional examines the soils, landscape features, and past surveys of the potential site. He or she makes special note of the location of nearby wells, other septic systems, the slope of the land, depth to the groundwater source and to impermeable layers (such as bedrock), natural drainage patterns, and the boundaries of the lot.

An important feature of the site evaluation is a thorough study of the soil. Marking the position of the absorption field, the sanitarian digs an observation pit to examine the soil layers for texture, structure, and color patterns that will give clues about the soil's permeability and potential for seasonal water saturation.

WARNING

Toxic gases, including methane and hydrogen sulfide, are produced by the natural treatment processes in septic tanks. These gases can kill in minutes.

Extreme care should be taken when inspecting your tank, even when just looking in. Never enter a septic tank or try to inspect the tank alone. Most communities have licensed septic contractors who can inspect your system periodically. For guidelines on how to safely and properly inspect your system, call your local permitting authority.

Sometimes the sanitarian will conduct a percolation, or "perc," test to measure how quickly the water moves through the soil. In some states, other methods of testing soil permeability are used. Check with state and/or local permitting authorities to find out what method is used in your area.

A good site evaluation defines the limitations of a site. If the soil or other conditions are inappropriate for a conventional drainfield, workable alternatives can be designed using the data collected in the evaluation.

Poorly sited onsite systems may fail, causing inadequately treated wastewater to pond on the ground surface or to contaminate the groundwater.

If you are planning to construct an onsite system, be sure to contact your local permitting agency (often the local health department) for more information on site evaluation and permit requirements for your area.

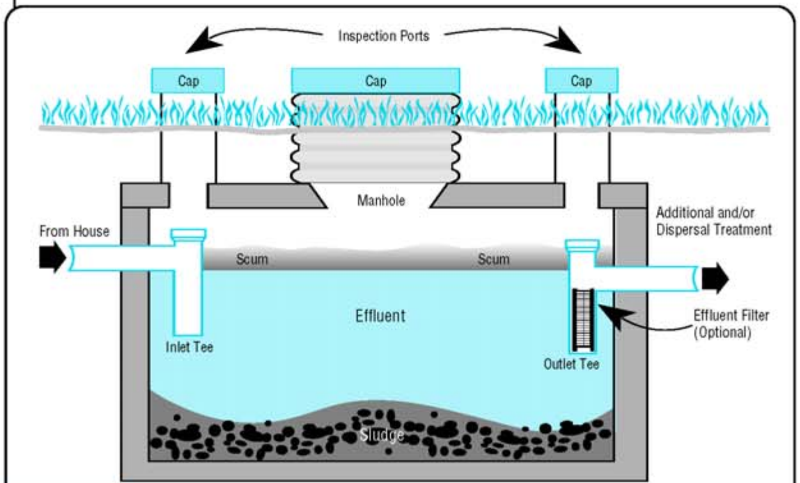

Figure 1a

Cross-section of a single compartment septic tank.

Figure 1b

Septic tank effluent filter.

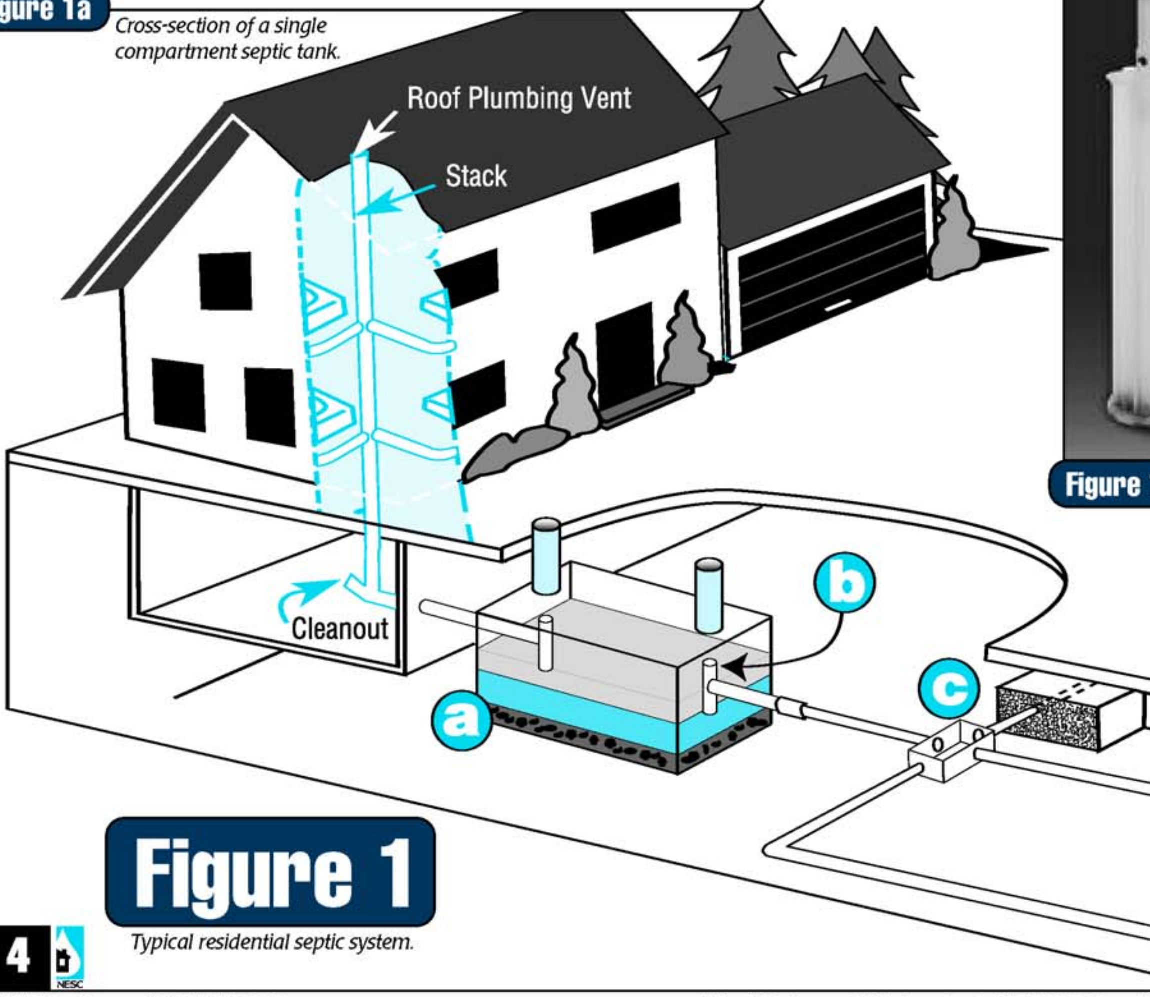

Figure 1

Typical residential septic system.

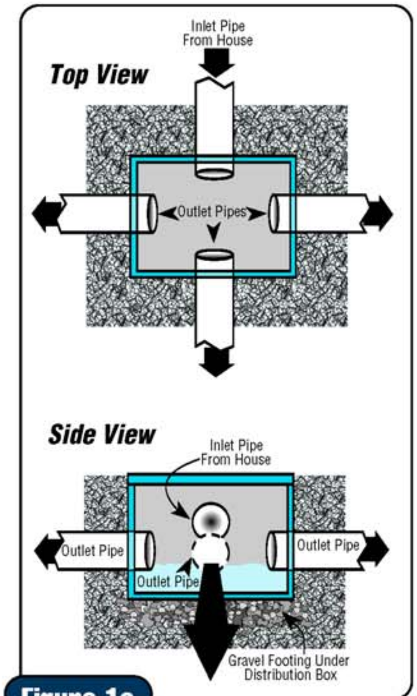

Figure 1c *Plan and cross-section views of distribution box.*

Distribution Systems for Drainfields

Conventional septic systems require the use of a distribution system to ensure that the flow of wastewater coming from the septic tank is evenly distributed to the different parts of the drainfield. Uneven distribution can overload areas of the drainfield, causing it to fail.

Following are descriptions of some of the most common distribution system components and methods.

Distribution Box

A distribution box is a tank-like box with as many outlets as there are pipes or lines in the drainfield. (See Figure 1c.) The effluent, or partially treated wastewater, from the septic tank flows into the box and through the different outlets to the drainfield. Because the outlets in the box are level with each other, and because this system relies on gravity to work effectively, it is important that the distribution box be level. If the distribution box is not exactly level, the flow to the drainfield will be uneven.

Advantages of this distribution method include equal distribution, easy inspection (the top of the box opens), and the option of capping outlets to give certain drainfield trenches a chance to rest.

Drop Box

A drop box is also a very simple tank-like box designed for effluent distribution. A series of drop boxes can be used for distributing wastewater to drainfields on sloped sites using only gravity.

Inside the drop box, the pipe inlet is higher than the outlet, allowing the wastewater to flow downward to the drainfield trenches. A series of drop boxes can be arranged on the sloped site so that after the highest trench is saturated with wastewater, the flow continues on to the next drop box and trench below. Drop box outlets can also be capped to control the direction of flow and to give the saturated upper trenches a rest. (See Figure2.)

Siphons and Pumps

Some septic systems, because of site conditions, soil conditions, or design, cannot rely on gravity alone to efficiently distribute the flow of effluent from the septic tank to the drainfield. Siphons or

Landscaping Septic Systems

Planting is recommended for the soil absorption field as opposed to plastics, bark, or gravel. The vegetation helps with oxygen exchange and evaporation. Drought resistant plants, native to your area, should be considered.

Care should be taken to choose plants with non-invasive root systems to avoid infiltrating the drainfield area, possibly damaging or breaking pipes. For this reason, trees and large shrubs are not recommended. Any vegetation chosen should provide coverage for the drainfield all year long.

Grasses are the most recommended type of vegetation because of their high evapo-transpiration rate. Meadow grasses mixed with wildflowers may also be a good choice because they don't have to be mowed regularly. Fertilizers and pesticides may be used with caution. Be sure to read the manufacturer's directions for these products.

Some possible ground covers for sun include: bugleweed (ajuga), carpet heathers (calluga), cotoneaster, ground ivy (glechoma), kinnickinick (arctostaphylos), periwinkle (vinca), and soapwort (saponaria).

Possible shaded area covers are: bunchberry (cornus), chameleon (houtuynnia), ferns, mosses, sweet woodruff (gallium), wild ginger (asarum), and wintergreen (gaultheria).

These are just a small sample of plants that can be used. Contact your local Cooperative Extension Office for more information.

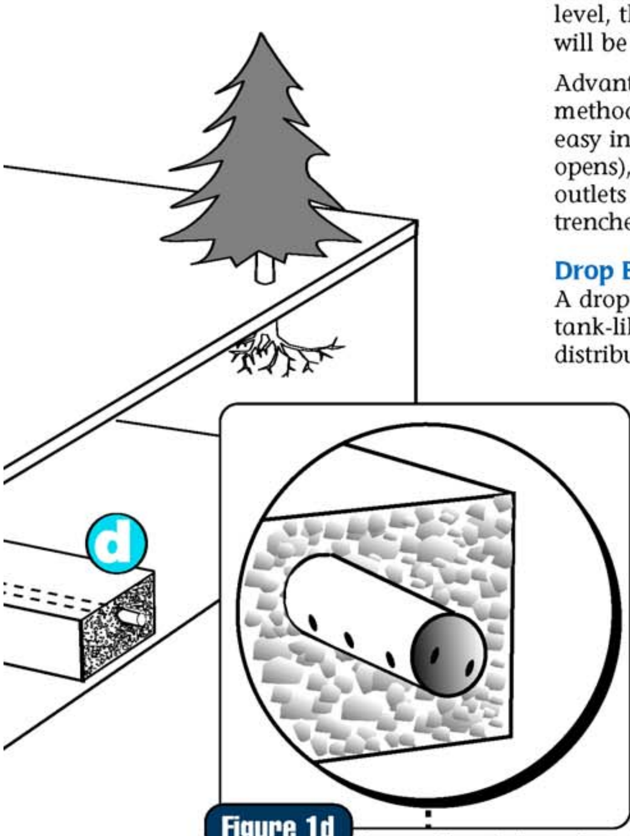

Figure 1d *Cross-section of pipe and gravel trench*

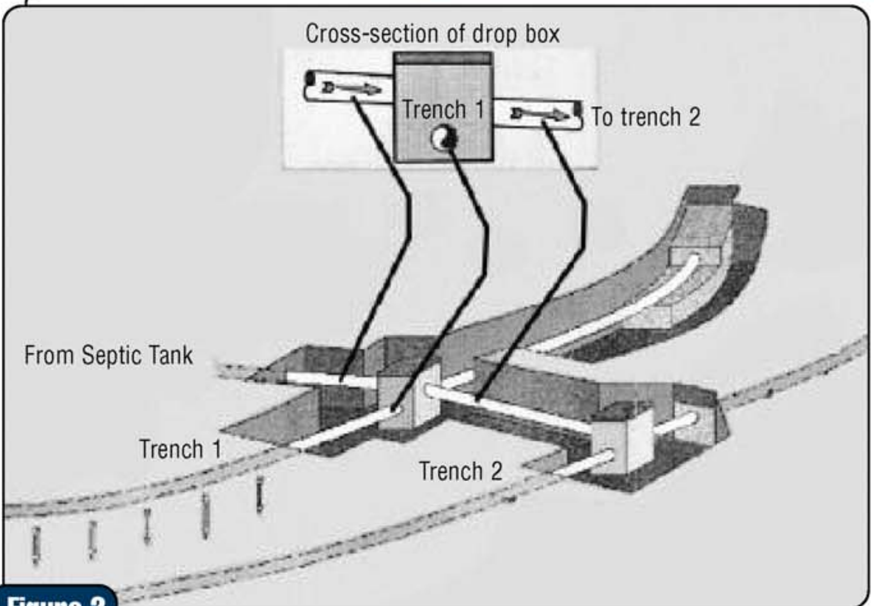

Figure 2 *Possible drop box configuration.*

pumps are sometimes used as a method of distribution with these systems.

Siphons are often used when septic tank effluent must be evenly distributed over a large area; for example, with drainfields using more than 500 feet of pipe. They are also used when the drainfield is downhill from the tank.The effluent flows from the siphon to the drainfield in pressurized doses, making uniform distribution easier to achieve. The effluent from the septic tank flows into a dosing tank, then through the siphon to the drainfield. Siphons work using only air, water pressure and gravity – no outside power source is necessary. (See Figure3.)

Siphons are a relatively low-cost technology that can improve the performance of the drainfield, but because they require approximately five feet of elevation difference between the septic tank outlet and the drainfield, they are unsuitable for many sites and septic system designs. They also require more maintenance than some other methods of distribution.

Electric pumps are also used to deliver controlled amounts or doses of effluent to the drainfield. Dosing can improve the performance of any drainfield by guaranteeing more uniform distribution, but it is especially advantageous for drainfields with shallow or poor soil conditions. However, electric pumps are more expensive to operate than other distribution systems, and they require regular maintenance. (See Figure 4.)

Some sites and drainfield designs require the use of electric pumps because the drainfield is higher than the septic tank, making it impossible to rely on gravity for distribution.

Alternating Fields

The life of a septic system can be significantly extended by having two drainfields and alternating their use. (See Figure 5.) When drainfields were first installed, it was initially believed that they had a limited life. The standard thought was that the field would eventually clog up completely, rendering itself useless.

Although the septic tank removed solids and floatables with the effluent passing to the SAS, the soil in the drainfield works as a filter to physically strain out waste, as well as a biological reactor. The soil particles serve as an attachment point for

Figure 3 *Siphon.*

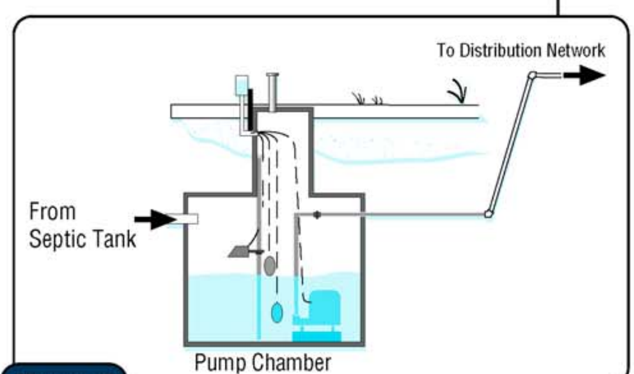

Figure 4 *Typical pump system.*

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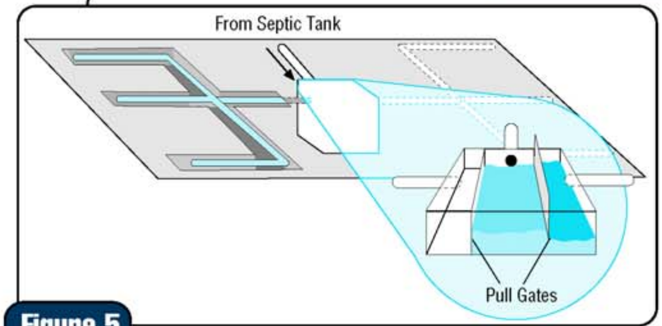

Figure 5
Alternating drainfields.

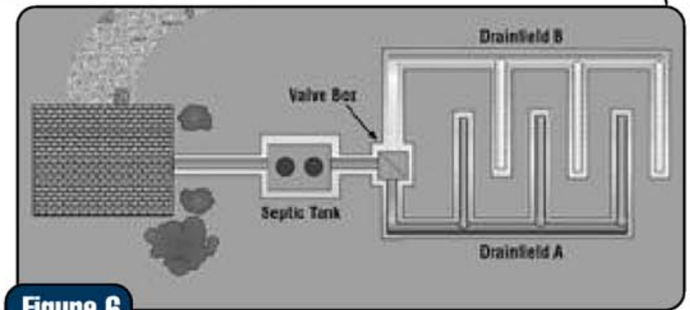

Figure 6
Interlacing drainfields.

bacteria where they feed on the waste in the effluent as it passes. When the bacteria feed, they grow and multiply, eventually forming a biological mat in the soil.

The current practice of alternating drainfields helps the long-term acceptance rate of a field so that the bacterial growth rate is balanced by the bacterial die-off rate. It allows one field to rest, while the other is being used. So in theory, the system never completely clogs.

Many factors, such as soil permeability, the amount of oxygen present, the hydraulic and biological loading rates, and the growth and death curves of the bacteria, make the practice of alternating drainfields a difficult science.

Although utilizing two drainfields does require a larger space, the two systems may be interlaced to reduce the amount of space needed. (See Figure 6.)

Water Conservation

Using water wisely can improve the operation of a septic system, greatly reducing the risk of failure. Using more water than the soil can absorb is the most common reason for septic system failure. The more a family conserves, the less water will enter the septic tank.

The average indoor water use in a typical single-family home is nearly 70 gallons per person per day. Toilets alone account for 25 to 30 percent of household water use. A leaky toilet can waste as much as 200 gallons per day.

High-efficiency toilets can also improve the function of a septic tank significantly, reducing the amount of water flushed from 3. 5- to 5-gallons per flush to 1.6 gallons of water or less per flush.

Septic System Cost

The cost of installing and maintaining a septic system varies greatly depending on its location and design. In most areas in the U.S., conventional septic systems cost from $2,500 to $7,500 to install. While certain site conditions or alternative drainfield designs can make installation more expensive, this is a general range for standard septic tank and soil absorption systems. Alternative septic systems requiring pumps or specially constructed drainfields can be considerably more expensive.

In order to accurately estimate what a septic system will cost, homeowners should contact their local permitting agency for more information about the costs of septic systems in their area.

As a general rule of thumb, septic systems are most cost-effective in communities where houses are spaced widely apart, and where connection to a sewer system is not an option. When the cost of operation and maintenance of a centralized treatment plant is factored in, residents in small rural communities may pay many times more per household for a centralized sewer system than residents in more densely populated areas. In certain communities, a centralized sewer system would be so expensive to install and maintain that costs per household could exceed property values.

In order to find the most cost-effective wastewater system for their homes, small community residents should discuss available options with local health department officials, neighbors, and community leaders.

When Conventional Septic Systems Are Used

Originally, septic systems were thought to be stop-gap measures to last until a neighborhood was sewered. It is now realized that some areas will never be connected to sewers, and that septic systems are perfectly capable of treating residential sewage. Indeed, in many cases, septic systems are the preferred solution for wastewater treatment.

Typically, in areas of low-housing density, septic systems work well. Onsite systems are more economical than running sewers between scattered houses. Large lot sizes allow the builder to find suitable soil and reduce the loading of effluent on the soil, improving treatment. It conserves water locally by treating the wastewater on site and returning it to the soil, rather than exporting it to a large treatment plant and discharging it to the surface waters.

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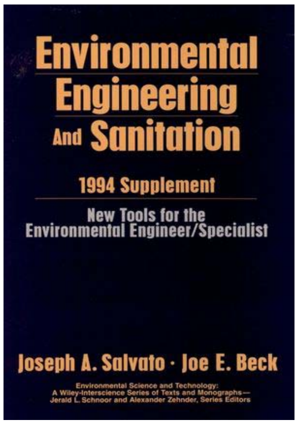

4

HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE

Dennis Fleetwood

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GENERAL

On October 17, 1986 the President signed into law the "Superfund Amendments and Reauthorization Act of 1986 (SARA)," which directed the Secretary of Labor to issue an interim final rule to provide protection for workers engaged in operations that include hazardous waste site cleanup, emergency response to hazardous substance incidents, and operations in permitted or interim status hazardous waste facilities.[1] Both the interim final rule and the final rule were adopted by the Occupational Safety and Health Agency (OSHA), which has given life to a program known as "HAZWOPER" or hazardous waste operations. The program hinges on key components which include:

- Safety and health program
- Site characterization
- Site control
- Personal protection
- Training
- Monitoring
- Handling drums and containers
- Decontamination
- Emergency response at uncontrolled hazardous waste sites
- New technology
- Operations at treatment, storage, and disposal (TSD) facilities

[1]*Federal Register*, 51, 244 (December 19, 1986).

- Sanitation of temporary field workplaces
- Emergency response to hazardous substance releases
- Medical surveillance

SCOPE

The HAZWOPER requirements apply to operations which include clean-up activities required by a governmental body; corrective actions involving clean-up operations under RCRA; voluntary clean-ups at uncontrolled hazardous waste sites; operations involving hazardous wastes at treatment, storage, and disposal (TSD) facilities; and emergency response operations for releases of hazardous substances.[2] The health and safety requirements set forth in this program were intended to provide a safe working environment in special circumstances; however, these requirements do not supersede more stringent OSHA requirements which may overlap in some areas of worker protection.

SAFETY AND HEALTH PROGRAM

Employers are required to develop and implement a written safety and health program for their employees involved in hazardous waste operations. The program must be designed to identify, evaluate, and control safety and health hazards and provide for emergency response for hazardous waste operations.[3]

The written safety and health program must incorporate the following:

- Organizational structure
- Comprehensive work plan
- Site-specific health and safety plan
- Safety and health training program
- Medical surveillance program
- Standard operating procedures for safety and health
- Any necessary interface between general program and site specific activities[4]

SITE CHARACTERIZATION

Hazardous waste sites must be characterized prior to general site entry to determine the hazards present at the site, and monitoring of hazards must be continued

[2]U.S. Department of Labor, Occupational Safety and Health Administration, *29 CFR 1910.120*, "Hazardous Waste Operations and Emergency Response," *Federal Register*.

[3]U.S. Department of Labor, Occupational Safety and Health Administration, *29 CFR 1910.120*, "Safety and Health Program," *Federal Register*.

[4]U.S. Department of Labor, Occupational Safety and Health Administration, *29 CFR 1910.120*, "Safety and Health Program, General," *Federal Register*.

during site operations. The site characterization information is used for determining the level of personal protective equipment required for those who work at the site. The initial site characterization is conducted with direct reading instruments, which can identify combustible atmospheres, oxygen deficiency, and toxic substances. If at any time during the site operations the monitoring equipment shows a change in the hazard conditions, the level of personal protection must be reevaluated.

SITE CONTROL

Site control measures must be developed before clean-up work begins. The site control program shall, as a minimum, include: a site map, site work zones, the use of a buddy system, site communications including alerting means for emergencies, the standard operating procedures or safe work practices, and identification of the nearest medical assistance.[7]

TRAINING

Those who work on hazardous waste sites are required to receive a minimum 40 hours of training and an additional 3 days of on-site field experience under a trained supervisor. Those who work at the site only occasionally and are not likely to be exposed to hazards above permissible exposure limits are required to receive 24 hours of instruction and 1 day of field experience prior to working at the hazardous waste site. Those workers involved in waste operations at TSD facilities are required to receive 24 hours of instruction before working in hazardous waste operations.

Site supervisors must have an additional 8 hours of instruction before working on hazardous waste sites in a supervisory capacity. All workers are required to undergo an 8-hour refresher training annually.

MONITORING

Air monitoring shall be performed in order to ensure proper selection of engineering controls, work practices, and personal protective equipment so that employees are not exposed to levels that exceed permissible exposure limits or published exposure levels for hazardous substances.[8] This monitoring should be directed by a person knowledgeable about industrial hygiene practices.

MEDICAL SURVEILLANCE

Employers must provide a medical surveillance program for workers at hazardous waste sites. The program shall include medical examinations initially, annually (unless the physician determines longer, up to biennially), when a worker develops signs or symptoms of exposure, and at termination or reassignment.

The employer is required to pay for the medical examination.

INFORMATIONAL PROGRAMS

Employers are required to develop and implement a program, which is part of the employer's safety and health program, to inform employees, contractors, and subcontractors actually engaged in hazardous waste operations of the nature, level, and degree of exposure likely as a result of participation in such hazardous waste operations.[7]

HANDLING DRUMS AND CONTAINERS

Hazardous and contaminated substances which are found on hazardous waste sites must be placed in proper shipping containers prior to being shipped off site for disposal. Precautions must be taken on site to minimize exposure of workers to hazardous or radioactive materials when containers are being removed, sampled, or otherwise handled. Containers used in the site clean-up operations must be marked and labeled in accordance with OSHA and U.S. Environmental Protection Agency (EPA) regulations, and they must be labeled in accordance with U.S. Department of Transportation (DOT) regulations prior to shipment off site.

DECONTAMINATION

Standard operating procedures shall be developed to minimize employee contact with hazardous substances or equipment that has contacted hazardous substances.[8] Personal protective equipment, decontamination solvents, and other equipment shall be decontaminated or disposed of properly. If equipment or clothing is sent to off-site facilities for cleaning, the hazards associated with the equipment must be communicated to the off-site facility.

EMERGENCY RESPONSE AT UNCONTROLLED HAZARDOUS WASTE SITES

Employers shall develop and implement an emergency response plan to handle emergencies. The elements of the emergency plan will contain, as a minimum, the following:

- Preemergency planning
- Personnel roles, lines of authority, and communication
- Emergency recognition and prevention
- Site security and control
- Evacuation routes and procedures
- Decontamination procedures that are not covered by the site safety and health plan
- Emergency medical treatment and first aid
- Emergency alerting and response procedures
- Critique of response and follow-up
- PPE and emergency equipment[9]

SANITATION OF TEMPORARY FIELD WORKPLACES

Potable drinking water and toilets must be provided for workers at hazardous waste sites. Both potable and nonpotable (if on-site) water containers must be labeled accordingly. Also, showers must be provided if the clean-up operations will require more than 6 months to complete.

NEW TECHNOLOGY PROGRAMS

Employers must develop programs to introduce new technology in its procedures to protect the safety and health of hazardous waste workers.[10]

OPERATIONS AT TSD FACILITIES

Permitted and interim status treatment, storage, and disposal facilities must meet safety and health standards similar to those required for clean-up operations at uncontrolled hazardous waste sites. The required duration of initial training for

workers at TSD's is 24 hours rather than the 40 hours required for workers at uncontrolled hazardous waste sites.

EMERGENCY RESPONSE TO HAZARDOUS SUBSTANCE RELEASES

Employees whose job it is to handle emergency response activities are also covered by the HAZWOPER program. The requirements for this program are similar to those of the uncontrolled hazardous waste site worker, although the training requirements are tailored more to specific categories of workers. Training for specialized employees is categorized into first responder awareness level, first responder operations level, hazardous materials technician, hazardous materials specialist, and on scene incident commander.

5

THE INSTITUTIONAL ENVIRONMENT: BIOSAFETY

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The practice of biosafety is largely accomplished within the institutional environment, particularly at research universities, medical schools/hospitals, government laboratories, and specific industrial laboratories. The term biosafety is a combination of biohazard and safety and refers to those practices used to reduce risks associated with biohazardous agents and is focused on personnel working in research, health care, or industrial environments. A biohazard according to the *American Heritage Dictionary* is "a material of biological composition, especially if infective in nature, that constitutes a threat to man or his environment."[1] Occupational exposures to infectious agents would fall within the concerns of biosafety whereas community exposures would traditionally remain in public health/environmental health. Biosafety and environmental health are both involved in risk assessment and risk management; the differences are the location of practice and the constituencies served. There is overlapping of course because the same agents and types of hazards may cause disease in either the workplace or the community. For example, Salmonella sp. may cause gastrointestinal disease when consumed with food (foodborne disease) and likewise when consumed by mouth pipetting cultures in the laboratory. Knowledge of the principles of epidemiology, disease transmission patterns, risk assessment, management, disinfection and sterilization (and sanitization), disease prevention, aerobiology, and environmental control is primary to both the biosafety officer and the environmental health practitioner.

Nosocomial infections lead to implementation of infection control (aseptic techniques and sanitation) in hospitals and other health care institutions due to concern for the patients/clients. These administrative policies and practices were emphasized or relaxed based on technical knowledge, the availability of effective antibiotics, accreditation standards, federal, state, and local regulations, and

[1] *American Heritage Dictionary, The*. 2nd College Edition, The Houghton Mifflin Company, Boston, Massachusetts, 1985.

expressed concern of the professional community. Personnel working in the area of infection control has grown over the years and now have at least two professional societies devoted to infection control and epidemiology. In addition, the American Biological Safety Association, a multidisciplinary professional organization, was founded in 1984 for the purpose of fostering and promoting biological safety as a scientific profession. This formal development followed nearly 30 years (since the late 1950s) of meetings identified as the "Annual Biological Safety Conference."

Concern with safety of personnel followed the occurrence of laboratory acquired infections which routinely followed the discovery of agents that caused various diseases. In the early 1970s, with the advent of recombinant DNA (rDNA) technology, concern for safety (biosafety) was expressed by a committee of scientists.[2] This concern was followed by a conference to discuss the issues (Alisomar Conference) and later to the NIH developing a guideline for research involving recombinant DNA. The most current version of the National Institutes of Health (NIH) Guideline continues to guide research with recombinant DNA in the laboratory setting and regulations adopted by U.S. Department of Agriculture (USDA)/Animal and Plant Health Inspection Service (APHIS) and existing regulations of the Environmental Protection Agency (EPA) control the release of genetically engineered materials to the environment. Other federal agencies will look at the safety of genetically engineered foods, human or animal drugs and vaccines, and other consumer products.

REGULATIONS

A variety of federal and state laws and regulations have been promulgated to cover biohazards. National Institutes of Health (NIH) developed guidelines for recombinant DNA research as a result of the Alisomar conference. The first NIH Guideline was issued June 23, 1976 and the first revision published in the *Federal Register* of July 28, 1978. Those guidelines established standards by which research involving the new recombinant DNA technology could be conducted including biological and physical containment strategies and protocol reviews at both the institutional and federal (NIH) levels, and identified the roles and responsibilities of various players. The latest NIH Guideline was published in the May 7, 1986 Federal Register. Since the original Guideline was published in 1976, it has been periodically revised and updated. The 1986 Guideline emphasizes again that they are intended to help Institutional Biosafety Committees (IBC), the Biological Safety Officers, and the Principal Investigators determine the safeguards to implement with projects involving recombinant DNA techniques. The Guidelines will never be complete nor final and therefore it is the responsibility of the institution and those associated with it to adhere to the intent of the Guidelines as well as the specifics. This statement could probably be made for all environmental health regulation and guidance. The guidelines provide guidance by identifying the responsibilities of the Institution, the IBC, the Biosafety Officer, the Principal Investigator, and the NIH. Additionally, those types of experiments that require approvals from the Recombinant DNA Advisory Committee (RAC) and the NIH and the IBC are identified.

The USDA/APHIS published final rules in the June 16, 1987 *Federal Register* covering the "Introduction of Organisms and Products Altered or Produced Through Genetic Engineering Which are Plant Pests or Which there is Reason to Believe are Plant Pests." Enforcement of these regulations initially relied on a series of reviews, permits, and inspections conducted by APHIS. In the March 31, 1993 *Federal Register*, USDA/APHIS published updated regulations under the same title as the 1987 regulations. The updated version allows for notification of the USDA rather than obtaining a permit for introduction of selected plant species including: corn (*Zea mays L.*); cotton (*Gossypium hirsutum L.*); potato (*Solanum tuberosum L.*); soybean (*Glycine max [L.] Merr.*); tobacco (*Nicotiana tabacum L.*); and tomato (*Lycopersicon esculentum L.*). The USDA uses performance standards for introductions under the notification procedure. This procedure is intended to reduce the regulatory burden based on experience gained from more regulated field trials. Close cooperation with the Institutional Biosafety Committees and Biosafety officers and the APHIS compliances officers was experienced by many institutions. Currently more active participation of the IBCs is sought by the regulatory agency.

Occupational Safety and Health Act (OSHA) Bloodborne Pathogen regulations were published in the December 6, 1991 *Federal Register* following considerable discussion and input from a variety of constituencies. The purpose of this regulation is to eliminate or minimize occupational exposure to Hepatitis B (HBV), Human Immunodeficiency Virus (HIV), and other bloodborne pathogens. The regulations became effective March 6, 1992. The scope of this regulation is limited to pathogenic microorganisms that are present in human blood and may cause disease in humans as a result of an occupational exposure. Control measures are based on "universal precautions" under which all human blood and certain other human body fluids are considered to be infectious and are handled accordingly. Work practices, safety (containment) equipment, and facility design identified for biosafety levels 2 and 3 are appropriate for handling most characterized bloodborne pathogens. The development and maintenance of an exposure control plan is another requirement of the OSHA regulations on bloodborne pathogens. This particular requirement really initiates the risk management program for each affected institution.

The Medical Waste Tracking Act of 1988 was signed into law on November 1, 1988. This act required the U.S. EPA to establish a two year demonstration program for tracking medical waste in selected states. In the March 24, 1989 *Federal Register* the Environmental Protection Agency published an interim final rule and request for comments for the "Standards for the Tracking and Management of Medical Waste." This rule specified the procedures and criteria under which states could petition in or opt out of the demonstration program. It also listed the wastes identified by EPA as medical wastes for the Medical Waste Tracking Act. As a result of this federal initiative many states developed regulations for bio-

medical/infectious/medical wastes. Georgia's biomedical waste regulations are part of the broader solid waste management regulations as were those developed by other states. One effect of biomedical waste regulations has been increased safety in handling these wastes and the development of technology for treatment and disposal. Another effect has been the increased difficulty in landfill disposal of even properly treated biomedical wastes and significantly greater cost to the institutions handling biomedical wastes with questionable improvements in the public health.

Because regulations are periodically updated or revised, it is not the intent of this section to discuss them in detail. Rather the reader should become familiar with the *Federal Register* for federal laws and regulations, and appropriate state publications for state laws.

IMPLEMENTING BIOSAFETY PROGRAMS

Implementation of a biosafety program begins with an assessment of the risks associated with the research project or the types of patients and diseases or conditions being considered. An understanding of the infectious agent or recombinant molecule is required including route of exit and entry, mode of transmission, infectious dose, availability of treatment or vaccine. Based on these and other characteristics, agents are classified according to Biosafety Levels 1 through 4 where 1 is the least hazardous.

1. Biosafety level 1 agents are identified as well characterized agents not known to cause disease in healthy adult humans and are of minimal potential hazard to laboratory personnel and the environment.
2. Biosafety level 2 agents are of moderate potential hazard to personnel and the environment and include many of the food and waterborne disease agents such as Salmonella (except typhi), Shigella, and Campylobacter.
3. Biosafety level 3 agents are those indigenous or exotic agents that may cause serious or potentially lethal disease as a result of exposure by inhalation. Tuberculosis and the Hantavirus are examples of agents in biosafety level 3.
4. Biosafety level 4 agents are dangerous and exotic agents which pose a high individual risk of infection and life-threatening disease as a result of aerosol exposures.

The next characteristic is the concentration of agent being used or handled. The growth of large quantities of infectious agents requires special equipment and techniques. The quantity of materials is of concern in rDNA projects as well and the NIH Guidelines in Appendix K specifies containment for large-scale (greater than 10 L) uses. The use of large quantities or the concentration of infectious agents may require personnel to increase the biosafety level in order to conduct the work safely.

In addition to the characteristics of the agent, the activity to be conducted with the agent must be considered in the assessment. Those activities that may expose personnel to aerosols such as centrifugation, grinding, and blending receive particular attention and may result in an increased containment level. Containment is another key element in the implementation of biosafety programs and refers to those methods for safely managing infectious agents in the laboratory environment. The purpose of containment is to reduce or eliminate exposure of laboratory personnel, other persons in the facility, and the outside environment to potentially hazardous agents being handled in the laboratory or clinical setting. Containment is comprised of three elements: (1) laboratory practices and techniques; (2) safety equipment commonly identified as primary barriers, and (3) facility design or secondary barriers. Safety practices for the four biosafety levels have been identified by the Centers for Disease Control (CDC) and the NIH offices of biosafety. These practices are specified for both laboratory and animal facilities and would require some adjustment for other types of work activities.

BIOSAFETY LEVEL 1 CRITERIA FOR LABORATORIES AND ANIMAL FACILITIES

At biosafety level 1 (BSL-1) and all subsequent biosafety levels the following standard practices are identified:

1. Access to the laboratory or animal facility is restricted or limited at the discretion of the laboratory or facility director. The main purpose of restricting access is to reduce potential exposure by controlling the numbers of people in the laboratory/facility and restricting persons with preexisting conditions such as pregnancy or increased susceptibility.

2. Personnel are to wash their hands after handling viable materials and animals, after removing gloves, and before leaving the laboratory. Such hygiene is important in reducing exposure due to contact and ingestion. Gloves are incomplete in their protection and may lead personnel into a false sense of security.

3. Another prohibition aimed at reducing exposure to biological and chemical agents in the laboratory, specific and appropriate for most work places, is refraining from eating, drinking, smoking, applying cosmetics, and handling contact lens. Those individuals wearing contact lens should also wear eye protection in the form of safety goggles.

4. Mechanical pipetting devices provide accuracy and safety in transferring hazardous agents and have largely replaced mouth pipetting. However, it is still necessary to include a prohibition on mouth pipetting since this practice is used periodically.

5. The production of aerosols containing hazardous agents has been reported as the most important exposure in a number of studies.[3-5] Work practices emphasize the

minimization of spills, splashes, and production of aerosols. Containment devices such as the biological safety cabinet (BSC) are routinely used to reduce exposure from aerosols.

6. All cultures, stocks, and other regulated wastes are decontaminated by an approved method (i.e., autoclaving) before disposal. Stress has always been placed on the proper handling and disposal of infectious wastes from both hospitals and research laboratories. Autoclaving and incineration were methods of choice and were readily available. However, as environmental health concerns with air pollution reduced the number of incinerators, including pathological incinerators, other options for disposal became necessary. Additionally, the finding of needles and syringes and other biomedical wastes on beaches and in vacant lots during 1987 and 1988 generated much negative publicity and increased the pressure for regulations and a search for new technologies.

7. Effective insect and rodent control programs are implemented. The attempt to control the release of biohazardous agents is laudable but it must be remembered that these materials may also be carried from the laboratory or workplace on shoes, clothing, and other inanimate and animate objects.

8. Work surfaces are routinely decontaminated with an effective disinfectant (basic sterile technique would identify that proper disinfection of work surfaces is completed both prior to and following the work to be accomplished. Of course, surfaces are to be cleaned and disinfected following any spill of viable materials.

No special practices are identified by CDC and NIH[6] for biosafety level 1. Basic laboratory protective clothing (laboratory coats, aprons, gowns, etc.) should be worn to protect street clothing and gloves should be used when personnel has broken skin or a rash on the hands.

BIOSAFETY LEVEL 2 SPECIAL PRACTICES AND EQUIPMENT

Biosafety level 2 (BSL-2) initiates basic containment practices that are important for the microbiological research or clinical laboratory. The containment practices relies heavily on sterile technique that students learn in elementary bacteriology courses as well as the other standard practices identified for BSL-1. Special practices include: (1) *Appropriate training* on the potential hazards and *appropriate immunizations* or tests for agents used or present in the laboratory for all laboratory personnel. (2) Baseline serum samples may be desirable. (3) The laboratory or institution will have prepared a *biosafety manual* and such manuals are used in training personnel. An institution may adopt a biosafety manual and additionally have individual laboratories develop standard operating procedures (SOPs) specific

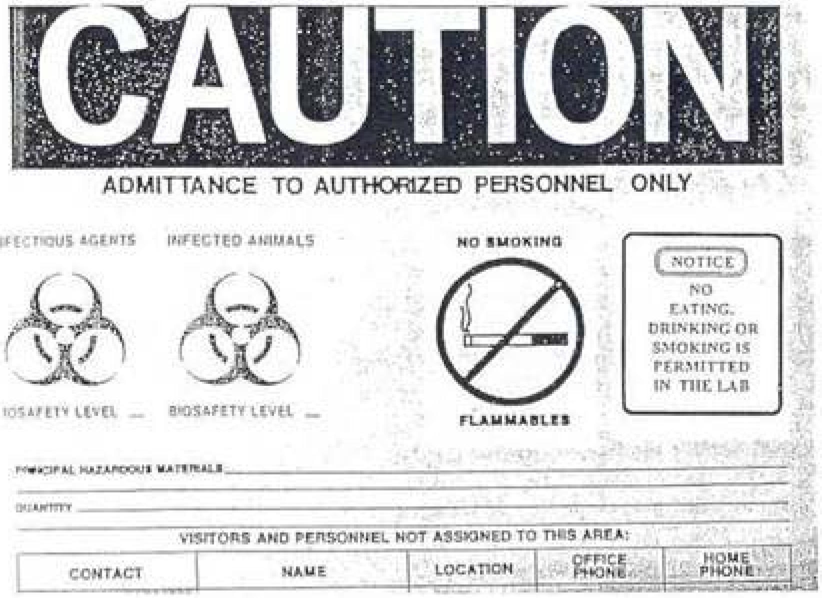


Figure 5–1 Example of door signs used at the University of Georgia.

for the conditions and agents present. This practice works well in that it involves laboratory personnel in reviewing the risks and developing solutions that they will implement. (4) Warning signs to inform persons entering the laboratory of the potential hazards are placed on the laboratory door when infectious agents are used. These door signs are unique for each institution but all should have the universal biohazard symbol displayed and identify the infectious agent(s) in use or storage, how to contact responsible laboratory personnel, and any special requirements (i.e., special immunizations) for entering the laboratory (see Figure 5–1). (5) A high degree of precaution is taken with sharp items including needles and syringes, scalpels, pasteur pipettes, and microscope slides. (6) Greater care is taken in decontaminating work surfaces and equipment, including animal cages which should be autoclaved prior to cleaning and washing; handling, storage, and processing infectious wastes. And, (7) all spills and accidents involving exposure to infectious materials are reported immediately to the laboratory director and the institutional biosafety officer. Reporting procedures for accidents vary according to the requirements of each institution and outside regulatory agencies. The primary purpose of reporting is to identify the facts surrounding the accidental exposure and search for preventive measures, not to find fault with individuals involved.

At BSL-2 safety equipment and facilities play an increasingly important role. Class II biological safety cabinets may be required particularly when laboratory procedures have the potential for creating aerosols of infectious materials. The

researcher may desire to use the biological safety cabinet to provide a clean environment in which to work with sensitive materials. At this point a couple of questions arise. What are biological safety cabinets and how are they different from fume hoods and clean benches? Important differences exist and must be understood in order to assure the safety of the users, other laboratory occupants, and all associated personnel and contractors.

FUME HOODS

Fume hoods are part of the local exhaust system that is dedicated and designed to protect personnel and the laboratory from hazardous chemicals by capturing airborne material in a flow of air (generally 90 to 125 linear feet per minute) at the work surface and exhausting it through ducts to the air above the building's roof. Usually the air stream is not filtered or treated, although with certain radioisotopes, filters may be inserted. Point source air pollution controls may be required in some urban areas. Fume hoods do not provide product protection and should not be used with infectious agents because of filtration. The only routine performance test for fume hoods is a check of the air velocity at the face of the hood. Smoke tests involve the release of artificial smoke within the hood to determine the structural integrity of the duct or air turbulence within the hood.

CLEAN BENCHES

A clean bench is a cabinet designed to move room air through a high-efficiency particulate air filter (HEPA) and direct the filtered air in an unidirectional manner over a work surface. Because this airflow is commonly directed toward the user, clean benches provide product protection only and are not to be used with biohazardous agents or unknowns. A clean bench should be considered only when there is no possible risk to personnel from direct airborne exposure. Air flow velocity and filter integrity testing are the performance tests usually accomplished on clean benches.

BIOLOGICAL SAFETY CABINETS

Biological safety cabinets (BSCs) are ventilated cabinets where ambient room air is drawn into a front opening for personnel protection and directed through HEPA filters before being exhausted back into the room or into the buildings exhaust system. In Class II BSCs part of the air entering the cabinet is filtered and recirculated in an unidirectional manner over the work space to provide for product protection. The biological safety cabinet, therefore, is designed to protect personnel, the work being done in the cabinet, and the environment from infectious aerosols. Three types of BSCs are in use and are identified as Class I, Class II (includes four types—A, B1, B2, and B3); and Class III. Class II BSCs are most commonly used in both research and clinical laboratories. Personnel are protected by the inflow of air through the work access opening while filtration protects the work inside the BSC and the laboratory environment. Biological safety cabinets are equipped with high efficiency particulate air (HEPA) filters which are designed and tested for removing 99.97 to 99.99 percent of particles 0.3 μm or larger. The filters due to air flow characteristics will remove smaller particles. HEPA filters are particulate/aerosol filtration devices and are neither effective with nor intended for use with gases or fumes. Class II type A cabinets are not typically exhausted to the outside air (Class II type B cabinets are always exhausted outside), therefore, they should not be used with volatile toxic chemicals or radionuclides. Biological safety cabinets should be performance tested (certified) at least once per year. BSCs are frequently certified every 6 months in health care institutions. A national performance standard (NSF 49) has been developed by the National Sanitation Foundation and is used to evaluate the design, construction, and performance of biological safety cabinets.

As the user reviews his/her equipment needs, the selection of the appropriate exhaust ventilation device should begin with a knowledge and intended use of each type.

LEVEL 3 SPECIAL PRACTICES AND EQUIPMENT

The biosafety level 3 is the first containment level in which facility design and containment equipment play a major role. Laboratory practices are more exacting since personnel are working with agents that may cause serious or potentially lethal disease as a result of exposure by inhalation of aerosols or particulates. The biological safety cabinet, discussed under Biosafety Level 2, is required for all procedures involving the manipulation of infectious materials. Therefore, laboratory personnel must be trained in efficacious work practices in the biological safety cabinet. Special practices at level 3 build on those required at level 2 and include: (1) Laboratory doors are closed when experiments are in progress. The importance of this requirement lies in both limiting access to nonlaboratory personnel and in controlling air flows which may interfere with biological safety cabinets. (2) Special entry requirements such as immunization may be established and enforced by the laboratory or animal facility director. (3) Baseline serum samples are collected from all at-risk personnel and stored for comparisons periodically or following accidental exposures. (4) Animals and plants not related to the work being conducted are not to be allowed in the laboratory. Both may bring microorganisms into the laboratory and likewise may carry them out of the laboratory and into the community.

In addition to the BSC, containment devices such as sealed centrifuge rotors and filtered caging for animals is used as appropriate. Personal protective equipment (PPE) may be used with the containment equipment for additional protection and in those situations where work must be accomplished outside a biosafety cabinet or in animal rooms containing infected specimens. The laboratory facility is designed to be separated from areas that are open to unrestricted traffic and entry requires passing through two self-closing doors. Negative air pressure is maintained in the BSL-

3 laboratory by exhaust ventilation which draws makeup air from cleaner areas. The outside exhaust air must be dispersed away from occupied areas and building air intakes. All equipment that may produce aerosols (i.e., continuous flow centrifuges) are contained in devices that exhaust air through HEPA filters, the vacuum lines are protected with disinfectant traps or HEPA filters. All containment equipment or devices must be properly maintained and replaced as needed. Table 5-1 is a summary of recommended biosafety levels 1 through 3.

BIOSAFETY LEVEL 4

Biosafety level 4 has been described as a world within a world. It is the maximum in containment and depends heavily on facility design and containment equipment (i.e., Class III cabinets or glove boxes) or personnel protective equipment (i.e., positive pressure one-piece suits) for protecting the environment outside the laboratory. Training of personnel is vital since they will be handling extremely hazardous infectious agents under restrictive work conditions. Because there are very few BSL-4 facilities available in the United States this discussion has been abbreviated.

Biosafety programs are located organizationally to meet the management goals of each specific institution. One component of the biosafety program necessary to meet NIH guidelines is the appointment and maintenance of the Institutional Biosafety Committee. The IBC is comprised of no fewer than five persons selected so that there is a collective expertise and experience in recombinant DNA technology and the capability of assessing the safety of experiments and any potential risk to the public health and the environment. The role of the IBC does not have to be limited to recombinant DNA and at many institutions the IBC reviews any research that uses biohazardous agents. At least two members of the IBC shall not be affiliated with the institution other than as a member of the IBC and serve to represent the interest of the surrounding community. Persons with public health, environmental health, or environmental protection backgrounds as well as those in the medical community may be strong contributing members of the IBC. One member of the IBC is commonly the institutional biosafety officer. This is effective organization since the IBC and the Biosafety Officer work closely in implementing the institutional biosafety program.

Perhaps the most important feature of implementing successful programs in biosafety is a reliance on consultation and working with the client rather than depending on enforcement of regulations. This is the method that many of us were taught when we entered the field of environmental health. The working relationship built between the biosafety officer and the client (researcher, clinician, facility management) is based on knowledge, the desire to assist and be assisted, and a continuous effort to maintain honest communication. One member of the IBC is commonly the institutional biosafety officer. This is effective organization since the IBC and the Biosafety Officer work closely in implementing the institutional biosafety program.

Table 5-1 Summary of Recommended Biosafety Levels for Infectious Agents (Human)

Biosafety Level	Agents	Practices	Safety Equipment	Facilities
1	Not known to cause disease in healthy adults.	Standard microbiological practices—lab personnel receive appropriate training on potential lab hazards	None required.	Basic teaching lab with bench top sink required.
2	Associated with human disease. Hazards are from autoinoculation, ingestion, and mucous membrane exposure.	BSL 1 practices plus • Limited access • Biohazard warning signs • *Sharps* precautions • Biosafety manual/SOPs defining other specific practics see Sections IV, V, and VI of this manual • Waste disposal must follow state and federal regulations see Section III	Class II biosafety cabinets (BSC) or other physical containment devices used for all manipulations of agents that cause aerosols or splashes of infectious material; personal protective equipment—lab clothing, gloves, face and respiratory protection as needed.	BSL 1 plus autoclave available in building—if this autoclave is to be used with biomedical waste then it must be a functioning recording autoclave.
3	Indigenous or exotic strains of indigenous agents with a potential for aerosol transmission; causing human disesae, which may have serious or lethal consequences.	BSL 2 practices plus • Controlled access • Decontamination of lab clothing before laundering • Baseline serum sample	Class II BSC and other physical containment devices used for all manipulations of agents.	• BSL 2 plus autoclave in laboratory • Physical separation from access corridors • Self-closing, double door access • Exhausted air not recirculated in building • Negative air flow into laboratory

Source: Adapted from the CDC/NIH *Biosafety in Microbiological and Biomedical Laboratories*, HHS Pub. No. (CDC) 93-8395, May 1993.

Drinking Water, Recreational Water, and Wastewater

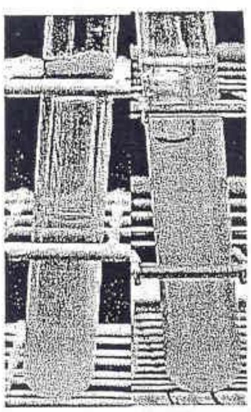
COLIFORM TESTING

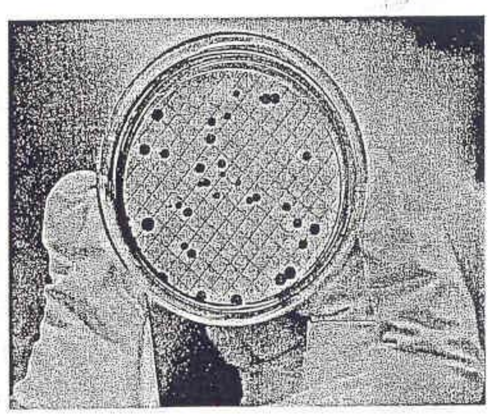
POWER POINT

By

Worley Johnson, Associate Professor

Eastern Kentucky University





What are coliforms?

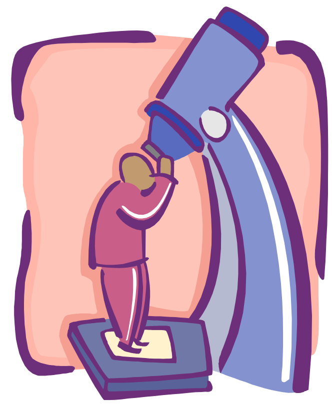
- Group of gram negative, aerobic to facultative anaerobic, non-spore forming rod shaped bacteria that ferments lactose at 35 ^{o} C in 24 to 48 hours.

Coliforms

- Are found throughout nature and found in the intestinal tract of all warm blooded animals, including humans
- Normal flora of the G.I. tract

Why sample for Coliforms Instead of Specific Pathogens?

- Isolating pathogens could be dangerous
- Impossible to find pathogens in a 100 ml sample
- Tests are expensive, difficult to perform with any consistency.



Collecting a Sample

- 100 ml is the correct size sample
- Sterile disposable whirl pacs or containers must be used
- Sterile technique must be pursued during testing

Total Coliforms

- **Total coliforms refer to the genera:**
  Escherichia, Enterobacter, Citrobacter, Klebsiella and

  are visible as red colonies on an M-endo media incubated at 35^o C for 24-48 hours.

Fecal Coliforms

- Refers to: Escherichia and Klebsiella only
- And seen as colonies with a green sheen on a MFc media incubated at 44.5 ^{o} C for 24-48 hrs.

Three Procedures for Coliform Testing

- Membrane Filtration
- Most Probable Number (MPN) also called multiple tube fermentation
- Presence/Absence Test
- Easy Gel- Pour plate

Other Coliform Tests

- MUG Tests-glucuronidase (an enzyme specific to e-coli) is hydrolyzed and fluoresces under a black light
- M-coli Blue-
- Colilert

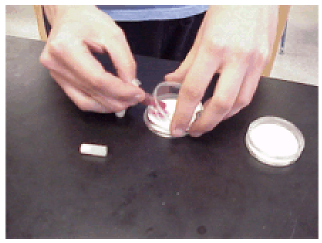
Membrane Filtration

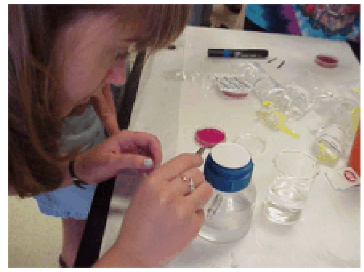
- MF apparatus
- Membrane filters
- Petri dish with pad
- Forceps
- Alcohol burner
- Appropriate media
- Vacuum pump
  - Manual hand held
  - Electric pump

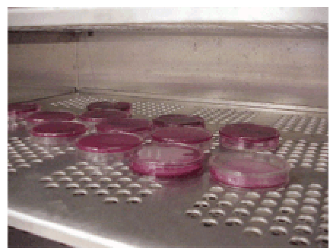
Membrane Filtration Steps

- Apply filter to funnel base with sterile forceps
- Pour in 100 ml sample
- Apply vacuum
- Take off filter from base with sterile forceps
- Roll filter onto pad saturated with media
- Invert and incubate

Membrane Filtration







Soil Evaluation Form

PAGE ______ OF ______

Health Department
Identification Number ____________
Map Number ____________

General Information

Date ____________ ____________ Health Department

Applicant ____________ Telephone No. ____________

Address ____________

Owner ____________ Address ____________

Location ____________

Subdivision ____________ Block/Section ____________ Lot ____________

Soil Information Summary

1. Position in landscape satisfactory Yes ☐ No ☐ Describe ____________

2. Slope ________%

3. Depth to rock/impervious strata Max. ______ Min. ______ None ______

4. Depth to seasonal water table (gray mottling or gray color) No ☐ Yes ☐ ______ inches

5. Free water present No ☐ Yes ☐ ______ range in inches

6. Soil percolation rate estimated Yes ☐ Texture group I II III IV
   No ☐ Estimated rate ______ min/inch

7. Percolation test performed Yes ☐ Number of percolation test holes ______
   No ☐ Depth of percolation test holes ______
   Average percolation rate ______

Name and title of evaluator: ____________

Signature: ____________

Department Use

☐ Site Approved: Drainfield to be placed at ____ depth at site designated on permit.

☐ Site Disapproved:

Reasons for rejection:

1. ☐ Position in landscape subject to flooding or periodic saturation.
2. ☐ Insufficient depth of suitable soil over hard rock.
3. ☐ Insufficient depth of suitable soil to seasonal water table.
4. ☐ Rates of absorption too slow.
5. ☐ Insufficient area of acceptable soil for required drainfield, and/or Reserve Area.
6. ☐ Proposed system too close to well.
7. ☐ Other Specify ____________

Site Evaluation

Field testing begins with a visual survey of the area to locate potential sites for subsurface soil absorption. Landscape position is evaluated to determine the best site location for the ground absorption system. Soil borings or test pits are dug in the area to observe soil characteristics. Depending on local regulations, percolation tests may be required in those soils that appear to be suitable. If no potential sites can be found from the visual survey and soil tests, an alternative means of disposal should be investigated or the site must be rejected. The following information blocks discuss all factors that determine site evaluations:

Topography or Slope

A. Definition: The deviation of the surface of the land from the true horizontal..Measured as the rise or fall (in feet) or fractions thereof. Expressed in percentage or degrees

B. Calculation: (Rise ÷ Run) x 100 = Slope

C. Suitability ratings:

0 – 15 %	**Suitable (S)**
15 – 30 %	**Provisionally Suitable (PS)**
>30 or complex slopes	**Unsuitable (U) ***

*May be upgraded to PS (except complex slopes) if:

1. Slopes can be terraced in 10 feet horizontal increments and;
2. Soil characteristics can be classified as PS or better to a depth of 30 inches

Landscape Position

A. Definition: The location of the proposed on-site wastewater disposal system area on a site relative to the surrounding topographic relief of the land surface.

B. Type of positions and their ratings:

	Convex	Concave
1. Hill or Ridge top	S	PS*
2. Shoulder slope	S	PS*
3. Side slope	S	PS*
4. Foot slope	PS	PS*
5. Toe slope	PS	PS*
6. Terrace	PS	PS*
7. Level Plains	S	-
8. Depression or sinkhole	-	U
9. Drainageways	-	U

*Unsuitbale unless 30 inches of PS soil is present and surface and subsurface water is diverted away from the area. Note: <u>FLOOD PLAINS</u> are rated suitable except when they stay flooded for 7 days or longer per year.

SOIL TEXTURE

A. Definition: The relative proportions of sand, silt, and clay in a soil including particles greater than 2 mm in diameter such as gravel, cobblestones, flagstones, chert, etc.

B. Textural classes

Group	Class	Rating	Application Rate Gpd/ft^2
1	Sand, Loamy sand	S	1.2 – 0.8
2	Sandy Loam, Loam	S	0.8 – 0.6
3	Silt Loam, Silty Clay Loam, Sandy Clay Loam, Clay Loam	PS	0.6 – 0.4
4	Silty Clay, Sandy Clay, Clay	PS	0.4 – 0.2
5.	Silty Clay , Sandy Clay, Clay	U	--

SOIL STRUCTURE:

A. Definition: The arrangement of the primary soil particles into clusters called peds or aggregates.

B. Structural Types:

1. Granular or Crumb: Rounded particles that are typically small in diameter. This structural type is found in the topsoil (A Horizons) and also found in the subsoil (B Horizons) of sandy soils.

2. Block like:
   Angular Blocky - Flattened sides with sharp corners (cube like).
   Subangular Blocky – Similar to angular blocky except corners are rounded.

3. Platy: Flattened sheets similar in shape to a dinner plate. Well defined horizontal planes of weakness with few vertical planes of weakness

4. Prismatic or columnar: Shaped like an optical prism. Typically found in fragipans

5. Massive: The absence of soil structure

Structure Ratings (May vary according to jurisdictions)

Type	Rating
GRANULAR OR CRUMB	S
Blocky Like	PS
Platy	U
Prismatic or columnar	U
Massive	U

Internal Soil Drainage

A. Definition: The soil drainage patterns below the surface of the ground which are affected by soli texture, soil structure, perched or permanent water tables, landscape and topography. It is determined through the use of the Munsell Color Chart to determine soil color.

B. Soil Colors: Used as an indicator of wetness. Colors indicate a seasonal wetness even in draught periods. Soil colors are described using three factors; hue, value, and chroma.

Soils with :

1. Reddish color (due to iron oxide) are well drained
2. Grey, yellow, olive, blue or white colors (due to lack of iron oxide) are poorly drained.

C. Soil Mottles: These are simply colors found in soil that differ from predominant (Matrix) color.

1. Abundance – the percentage of the soil sample that is occupied by mottles.
2. Size –

Very fine	< 1mm
Fine	< 1-2 mm
Medium	2 to 5 mm
Coarse	.5 – 10 mm
Very Coarse	> 10 mm

3. Contrast –
   a. Faint - indistinct mottles that are only evident upon close examination of the soil sample.
   b. Distant – Mottles that can be readily seen and easily distinguished from matrix color.
   c. Prominent – Very conspicuous mottles that can be

Soil Depth

A. Definition: The depth to bedrock, flagstones or weathered parent material (c. horizon)

B. Rating:

≥ 42 inches	S
< 42 inches to ≥ 24 inches	PS
< 24 inches	U

Available Space

A. Definition: The amount of space needed to properly install an on-site wastewater treatment system. This includes the area needed for the installation of a complete replacement/ repair system.

B. Rating:

100% initial system	S *
Anything else	U

* Note: In some jurisdictions, sites with group I or II soil may be rated suitable without any repair area.

Restrictive Horizons

A. Definition: A soil horizon; which due to it's cemented, compacted, or structural Condition, is relatively impermeable to the downward movement of water.

B. Types:

1. Fragipan- a dense soil horizon that is primarily composed of silt sized particles and is very dense and brittle due to its cement-like composition. Common cement-like materials include silicates, aluminum and sodium.

2. Iron pans- a dense soil layer that is cemented by iron and manganese oxides.

3. Clay pans- a restrictive layer formed from the a high concentration of clay-sized particles.
4. Plow pans- a compacted layer found in the lower limits of the plow depth of soil, caused by plowing wet ground. Platy and massive structures are commonly associated with this feature.

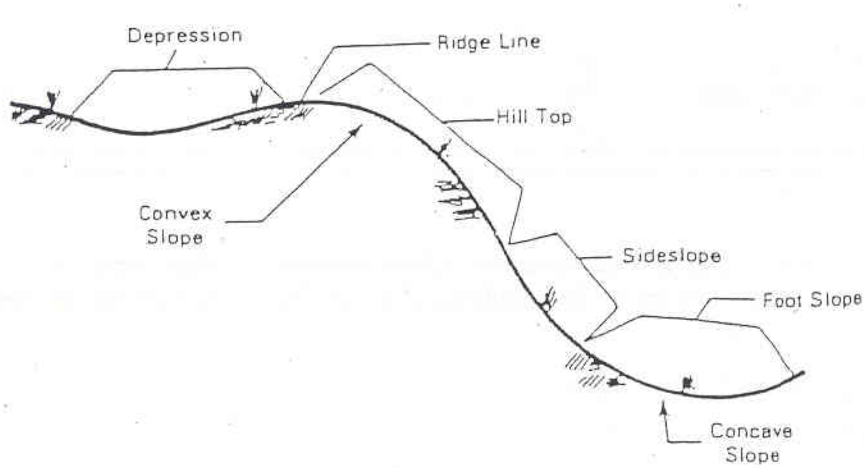
5. Platy structure- previously described

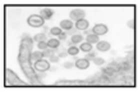
6. Hardpans- Dense layers generally formed from mechanical compaction.

7. Massive grade- The absence of soil structure

C. Rating: Rated based on the depth to one of these restrictive layers listed above:

≥ 42 inches	Suitable
< 42 to ≥ 24 inches	Provisionally suitable
< 24 inches	Unsuitable





Hantavirus Pulmonary Syndrome (HPS): What You Need To Know

RESERVOIR — The **deer mouse** *(Peromyscus maniculatus)* is the primary reservoir of the hantavirus that causes hantavirus pulmonary syndrome (HPS) in the United States.

TRANSMISSION — Infected rodents shed the virus through urine, droppings, and saliva. HPS is transmitted to humans through a process called **aerosolization**. Aerosolization occurs when dried materials contaminated by rodent excreta or saliva are disturbed. Humans become infected by breathing in these infectious aerosols.

HPS in the United States **cannot** be transmitted from one person to another.

HPS in the United States is not known to be transmitted by farm animals, dogs, or cats or from rodents purchased from a pet store.

RISK — Anything that puts you in contact with **fresh rodent urine, droppings, saliva or nesting materials** can place you at risk for infection.

VIRUS — Hantaviruses have been shown to be viable in the environment for **2 to 3 days** at normal room temperature. The ultraviolet rays in sunlight kill hantaviruses.

PREVENTION — **Rodent control** in and around the home remains the primary strategy for preventing hantavirus infection.

CLEANING — Use a **bleach solution or household disinfectant** to effectively deactivate hantaviruses when cleaning rodent infestations.

What is hantavirus pulmonary syndrome (HPS)?

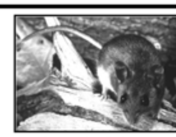
Hantavirus pulmonary syndrome (HPS) is a deadly disease transmitted by infected rodents through urine, droppings, or saliva. Humans can contract the disease when they breathe in aerosolized virus.

Who is at risk of getting HPS?

Anyone who comes into contact with rodents that carry hantavirus is at risk of HPS. Rodent infestation in and around the home remains the primary risk for hantavirus exposure. Even healthy individuals are at risk for HPS infection if exposed to the virus.

Which rodents are known to be carriers of hantavirus that cause HPS in humans?

In the United States, deer mice, cotton and rice rats (in the Southeast), and the white-footed mouse (in the Northeast), are the only known rodent carriers of hantaviruses causing HPS.



DEER MOUSE

How is HPS transmitted?

Hantavirus is transmitted by infected rodents through urine, droppings, or saliva. Individuals become infected with HPS after breathing fresh aerosolized urine, droppings, saliva, or nesting materials. Transmission can also occur when these materials are directly introduced into broken skin, the nose or the mouth. If a rodent with the virus bites someone, the virus may be spread to that person, but this type of transmission is rare.

Can you contract HPS from another person?

HPS in the United States cannot be transmitted from one person to another. You cannot get the virus from touching or kissing a person who has HPS or from a health care worker who has treated someone with the disease. In addition, you cannot contract the virus from a blood transfusion in which you receive blood from a person who survived HPS.

Can you contract HPS from other animals?

Hantaviruses that cause HPS in the United States are only known to be transmitted by certain species of rodents. HPS in the United States is not known to be transmitted by farm animals, dogs, or cats or from rodents purchased from a pet store.

Can you contract HPS from the tops of soda pop cans?

There is no evidence that hantavirus can be spread via soda cans. Wiping off the top of soda cans is good practice. However, if you fail to wipe off soda cans it is highly unlikely that an individual would become sick from

For more information regarding hantavirus pulmonary syndrome (HPS) and prevention, visit www.cdc.gov/hantavirus/.

hantavirus pulmonary syndrome. For more information, see Hoaxes and Rumors on the CDC Web page (http://www.cdc.gov/ncidod/hoaxes/hanta-hoax.htm).

How long can hantavirus remain infectious in the environment?

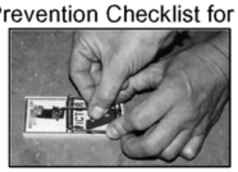
The length of time hantaviruses can remain infectious in the environment is variable and depends on environmental conditions, such as temperature and humidity, whether the virus is indoors or outdoors or exposed to the sun, and even on the rodent's diet (which would affect the chemistry of its urine). Viability for 2 or 3 days has been shown at normal room temperature. Exposure to sunlight will decrease the time of viability, and freezing temperatures will actually increase the time that the virus remains viable. Since the survival of infectious virus is measured in terms of hours or days, only active infestations of infected rodents result in conditions that are likely to lead to human hantavirus infection.

How do I prevent HPS?

SEAL UP, TRAP UP, CLEAN UP

Seal up rodent entry holes or gaps with steel wool, lath metal, or caulk. Trap rats and mice by using an appropriate snap trap. Clean up rodent food sources and nesting sites and take precautions when cleaning rodent-infested areas. See the HPS Prevention Checklist for a complete listing.

SEAL UP



TRAP UP

CLEAN UP

What are the recommendations for cleaning a rodent-infested area?

- Put on rubber, latex, vinyl or nitrile gloves.
- Do not stir up dust by vacuuming, sweeping, or any other means.
- Thoroughly wet contaminated areas with a bleach solution or household disinfectant.
  Hypochlorite (bleach) solution: Mix 1 and ½ cups of household bleach in 1 gallon of water.
- Once everything is wet, take up contaminated materials with damp towel and then mop or sponge the area with bleach solution or household disinfectant.
- Spray dead rodents with disinfectant and then double-bag along with all cleaning materials. Bury, burn, or throw out rodent in appropriate waste disposal system.
  (Contact your local or state health department concerning other appropriate disposal methods.)
- Disinfect gloves with disinfectant or soap and water before taking them off.
- After taking off the clean gloves, thoroughly wash hands with soap and warm water.

Can I use a vacuum with HEPA filter to clean up rodent-contaminated areas?

HEPA vacuums are not recommended since they blow air around and may create aerosols.

How do I clean papers, books, and delicate items?

Books, papers, and other items that cannot be cleaned with a liquid disinfectant or thrown away should be left outdoors in the sunlight for several hours or in an indoor area free of rodents for approximately 1 week before final cleaning. After that time, the virus should no longer be infectious. Wear rubber, latex, or vinyl gloves and wipe the items with a cloth moistened with disinfectant.

I do not want to bleach my clothes or stuffed animals; is there anything else I can do?

Wash clothing or stuffed animals in the washing machine using hot water and regular detergent. Laundry detergent can break down the virus's lipid envelope, rendering it harmless. Machine dry laundry on a high setting or hang it to air dry in the sun. CDC does not recommend simply running the clothing through the dryer without washing first.

How do I clean rugs, carpets and upholstered furniture?

Disinfect carpets and upholstered furniture with a disinfectant or with a commercial-grade steam cleaner or shampoo.

What precautions should I take if I think I have been exposed to hantavirus?

If you have been exposed to rodents or rodent infestations and have symptoms of fever, deep muscle aches, and severe shortness of breath, see your doctor immediately. Inform your doctor of possible rodent exposure so that he/she is alerted to the possibility of rodent-carried diseases, such as HPS.

Study Guide for the Kentucky Registered Sanitarian Test

Calculations:

There will be five to seven questions in the second part of the Registered Sanitarian Examination. Included in the back of the study guide are sample questions with step by step instructions toward solving each problem.

Constants used in all of the problems:

Gallon of water weighs	**8.34 pounds**
Converting cubic feet to gallons	**7.48**

The formulas for all problems are very similar.

3.1 CHEMICAL DOSAGE CALCULATIONS

CHLORINE DOSAGE

In chemical dosing, a measured amount of chemical is added to the water or wastewater. The amount of chemical required depends on such factors as the type of chemical used, the reason for dosing, and the flow rate being treated.

Two ways to describe the amount of chemical added or required are:

- milligrams per liter (mg/*L*)
- pounds per day (lbs/day)

To convert from mg/*L* (or ppm) concentration to lbs/day, use the following equation:

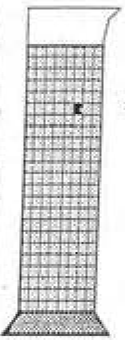
(mg/*L*)	(MGD)	(8.34)	= lbs/day
Conc.	flow	lbs/gal	

In previous years, parts per million (ppm) was also used as an expression of concentration. In fact, it was used interchangeably with mg/*L* concentration, since 1 mg/*L* = 1 ppm.* However, because *Standard Methods* no longer uses ppm, mg/*L* is the preferred expression of concentration.

MILLIGRAMS PER LITER IS A MEASURE OF CONCENTRATION

Assume each liter below is divided into 1 million parts. Then:

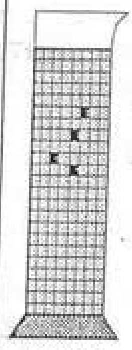
A



= 1 mg/*L* solids or 1 ppm solids

1 liter = 1,000,000 mg

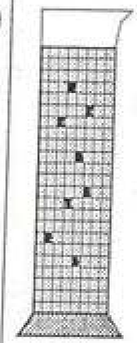
B



= 4 mg/*L* solids or 4 ppm solids

1 liter = 1,000,000 mg

C



= 8 mg/*L* solids or 8 ppm solids

1 liter = 1,000,000 mg

Assuming the liter in these three examples has been divided into 1 million parts (each part representing 1 milligram, mg), the **concentration of solids** in each liter could be expressed as:

- The number of mg solids per liter (mg/*L*) or
- The number of mg solids per 1,000,000 mg (ppm).

The concentration of solids shown in diagram A is 1 milligram per liter (1 mg/*L*). The solids concentration shown in diagrams B and C are 4 mg/*L* and 8 mg/*L*, respectively.

Example 1: (Chemical Dosage)

❑ Determine the chlorinator setting (lbs/day) needed to treat a flow of 3 MGD with a chlorine dose of 4 mg/*L*.

First write the equation. Then fill in the information given:

(mg/*L*)	(MGD)	(8.34)	= lbs/day
Conc.	flow	lbs/gal	

(4 mg/*L*) (3 MGD) (8.34 lbs/gal) = lbs/day

= $\boxed{\text{100 lbs/day}}$

* $\frac{1 mg}{L} = \frac{1 \text{ mg}}{1{,}000{,}000 \text{ mg}} = \frac{1 \text{ lb}}{1{,}000{,}000 \text{ lbs}} = \frac{1 \text{ part}}{1{,}000{,}000 \text{ parts}} = 1 \text{ ppm}$

Example 2: (Chemical Dosage)

☐ Determine the chlorinator setting (lbs/day) if a flow of 3.8 MGD is to be treated with a chlorine dose of 2.7 mg/*L*.

Write the equation then fill in the information given:

$$\underset{\text{Conc.}}{(\text{mg}/L)}\ \underset{\text{flow}}{(\text{MGD})}\ \underset{\text{lbs/gal}}{(8.34)} = \text{lbs/day}$$

$$(2.7\ \text{mg}/L)\ (3.8\ \text{mg}/L)\ (8.34\ \text{lbs/gal}) = \text{lbs/day}$$

$$= \boxed{85.6\ \text{lbs/day}}$$

Example 3: (Chemical Dosage)

☐ What should the chlorinator setting be (lbs/day) to treat a flow of 2 MGD if the chlorine demand is 10 mg/*L* and a chlorine residual of 2 mg/*L* is desired?

First, write the mg/*L* to lbs/day equation:

$$\underset{\text{Conc.}}{(\text{mg}/L)}\ \underset{\text{flow}}{(\text{MGD})}\ \underset{\text{lbs/gal}}{(8.34)} = \text{lbs/day}$$

In this problem the unknown value is lbs/day. Information is given for each of the other two variables: mg/*L* and flow. Notice that information for the mg/*L* dose is given only indirectly, as chlorine demand and residual and can be found using the equation:

$$\underset{\text{mg}/L}{Cl_2\ \text{Dose}} = \underset{\text{mg}/L}{Cl_2\ \text{Demand}} + \underset{\text{mg}/L}{Cl_2\ \text{Residual}}$$

$$= 10\ \text{mg}/L + 2\ \text{mg}/L$$

$$= 12\ \text{mg}/L$$

The mg/*L* to lbs/day calculation may now be completed:

$$(12\ \text{mg}/L)\ (2\ \text{MGD})\ (8.34\ \text{lbs/gal}) = \boxed{200\ \text{lbs/day}}$$

CHLORINE DOSAGE, DEMAND, AND RESIDUAL

In some chlorination calculations, the mg/*L* chlorine dose is not given directly but indirectly as chlorine demand and residual information.

Chlorine dose depends on two considerations—the chlorine demand and the desired chlorine residual such that:

$$\boxed{\underset{\text{mg}/L}{\text{Dose}} = \underset{\text{mg}/L}{\text{Demand}} + \underset{\text{mg}/L}{\text{Resid.}}}$$

The **chlorine demand** is the amount of chlorine used in reacting with various components of the water such as harmful organisms and other organic and inorganic substances. When the chlorine demand has been satisfied, these reactions stop.

In some cases, such as perhaps during pretreatment, chlorinating just enough to meet some or all of the chlorine demand is sufficient. However, in other cases, it is desirable to have an additional amount of chlorine available for disinfection.

Using the equation shown above, if you are given information about any two of the variables, you can determine the value of the third variable. For example, if you know that the chlorine dose is 3 mg/L and the chlorine residual is 0.5 mg/*L*, the chlorine demand must therefore be 2.5 mg/*L*:

$$3\ \text{mg}/L = 2.5\ \text{mg}/L + 0.5\ \text{mg}/L$$

If chlorine demand and residual are known, then chlorine dose (mg/*L*) can be determined, as illustrated in Example 3.

CHEMICAL DOSAGE FOR OTHER CHEMICALS

Examples 1-3 illustrated chemical dosage calculations for chlorine. The same method is used in calculating dosages for other chemicals, as shown in Examples 4 and 5.

Example 4: (Chemical Dosage)

❑ A jar test indicates that the best dry alum dose is 12 mg/*L*. If the flow is 3.5 MGD, what is the desired alum feed rate? (lbs/day)

$$\underset{\text{Conc.}}{(\text{mg}/L)}\ \underset{\text{flow}}{(\text{MGD})}\ \underset{\text{lbs/gal}}{(8.34)} = \text{lbs/day}$$

$$(12\ \text{mg}/L)\ (3.5\ \text{MGD})\ (8.34\ \text{lbs/gal}) = \text{lbs/day}$$

$$= \boxed{350\ \text{lbs/day}}$$

Example 5: (Chemical Dosage)

❑ To dechlorinate a wastewater, sulfur dioxide is to be applied at a level 3 mg/*L* more than the chlorine residual. What should the sulfonator feed rate be (lbs/day) for a flow of 4 MGD with a chlorine residual of 4.2 mg/*L*?

Since the chlorine residual is 4.2 mg/*L*, the sulfur dioxide dosage should be 4.2 + 3 = 7.2 mg/*L*:

$$\underset{\text{Conc.}}{(\text{mg}/L)}\ \underset{\text{flow}}{(\text{MGD})}\ \underset{\text{lbs/gal}}{(8.34)} = \text{lbs/day}$$

$$(7.2\ \text{mg}/L)\ (4\ \text{MGD})\ (8.34\ \text{lbs/gal}) = \text{lbs/day}$$

$$= \boxed{240\ \text{lbs/day}}$$

CALCULATING mg/*L* GIVEN lbs /day

In some chemical dosage calculations, you will know the dosage in lbs/day and the flow rate, but the mg/*L* dosage will be unknown. Approach these problems as any other mg/*L* to lbs/day problem:

- Write the equation,
- Fill in the known information,
- Solve for the unknown value.

Example 6: (Chemical Dosage)

❑ The chlorine feed rate at a plant is 175 lbs/day. If the flow is 2,450,000 gpd, what is this dosage in mg/*L*?

$$\underset{\text{Conc.}}{(\text{mg}/L)}\ \underset{\text{flow}}{(\text{MGD})}\ \underset{\text{lbs/gal}}{(8.34)} = \text{lbs/day}$$

$$(x\ \text{mg}/L)\ (2.45\ \text{MGD})\ (8.34\ \text{lbs/gal}) = 175\ \text{lbs/day}$$

$$x = \frac{175\ \text{lbs/day}}{(2.45\ \text{MGD})\ (8.34\ \text{lbs/gal})}$$

$$x = \boxed{8.6\ \text{mg}/L}$$

CHEMICAL DOSAGE IN WELLS, TANKS, RESERVOIRS, OR PIPELINES

Wells are disinfected (chlorinated) during and after construction and also after any well or pump repairs. Tanks and reservoirs are chlorinated after initial inspection and after any time they have been drained for cleaning, repair or maintenance. Similarly, a pipeline is chlorinated after initial installation and after any repair.

Digesters may also require chemical dosing, although the chemical used is not chlorine but lime or some other chemical.

For calculations such as these, use the mg/L to lbs equation:

$$\underset{\text{Conc.}}{(\text{mg}/L)}\ \underset{\text{Vol}}{(\text{MG})}\ \underset{\text{lbs/gal}}{(8.34)} = \text{lbs}$$

Notice that this equation is very similar to that used in Examples 1-6. The only difference is that MG volume is used rather than MGD flow; therefore, the result is lbs rather than lbs/day. (When dosing a volume, there is no time factor consideration.) Examples 7-8 illustrate these calculations.

Example 7: (Chemical Dosage)

❑ A storage tank is to be disinfected with a 50 mg/L chlorine solution. If the tank holds 70,000 gallons, how many pounds of chlorine (gas) will be needed?

$$\underset{\text{Conc.}}{(\text{mg}/L)}\ \underset{\text{Vol}}{(\text{MG})}\ \underset{\text{lbs/gal}}{(8.34)} = \text{lbs}$$

$$(50\ \text{mg}/L)\ (0.07\ \text{MG})\ (8.34\ \text{lbs/gal}) = \text{lbs}$$

$$= \boxed{29.2\ \text{lbs}}$$

Example 8: (Chemical Dosage)

❑ To neutralize a sour digester, one pound of lime is to be added for every pound of volatile acids in the digester liquor. If the digester contains 250,000 gal of sludge with a volatile acid (VA) level of 2,300 mg/L, how many pounds of lime should be added?

Since the VA concentration is 2300 mg/L, the lime concentration should also be 2300 mg/L:

$$\underset{\text{Conc.}}{(\text{mg}/L)}\ \underset{\text{Vol}}{(\text{MG})}\ \underset{\text{lbs/gal}}{(8.34)} = \text{lbs}$$

$$(2300\ \text{mg}/L)\ (0.25\ \text{MG})\ (8.34\ \text{lbs/gal}) = \text{lbs}$$

$$= \boxed{4{,}796\ \text{lbs}}$$

HYPOCHLORITE COMPOUNDS

When chlorinating water or wastewater with chlorine gas, you are chlorinating with 100% available chlorine. Therefore, if the chlorine demand and residual requires 50 lbs/day chlorine, the chlorinator setting would be just that—50 lbs/24 hrs.

Many times, however, a chlorine compound called hypochlorite is used to chlorinate water or wastewater. Hypochlorite compounds contain chlorine and are similar to a strong bleach. They are available in liquid form or as powder or granules. Calcium hypochlorite, sometimes referred to as HTH is the most commonly used dry hypochlorite. It contains about 65% available chlorine. Sodium hypochlorite, or liquid bleach, contains about 12-15% available chlorine as commercial bleach or 3-5.25% as household bleach.

Because hypochlorite is not 100% pure chlorine, **more lbs/day must be fed into the system to obtain the same amount of chlorine for disinfection.**

To calculate the lbs/day hypochlorite required:

1. First calculate the lbs/day chlorine required.

$$\underset{\text{Conc.}}{(\text{mg}/L)}\ \underset{\text{flow}}{(\text{MGD})}\ \underset{\text{lbs/gal}}{(8.34)} = \text{lbs/day}$$

2. Then calculate the lbs/day hypochlorite needed by dividing the lbs/day chlorine by the percent available chlorine.

$$\frac{\text{Chlorine, lbs/day}}{\frac{\%\ \text{Available}}{100}} = \text{Hypochlorite lbs/day}$$

Example 9: (Chemical Dosage)

❑ A total chlorine dosage of 12 mg/*L* is required to treat a particular water. If the flow is 1.2 MGD and the hypochlorite has 65% available chlorine how many lbs/day of hypochlorite will be required?

First, calculate the lbs/day chlorine required using the mg/*L* to lbs/day equation:

$$\underset{\text{Conc.}}{(\text{mg}/L)}\ \underset{\text{flow}}{(\text{MGD})}\ \underset{\text{lbs/gal}}{(8.34)} = \text{lbs/day}$$

$$(12\ \text{mg}/L)\ (1.2\ \text{MGD})\ (8.34\ \text{lbs/gal}) = \text{lbs/day}$$

$$= \boxed{120\ \text{lbs/day}}$$

Now calculate the lbs/day hypochlorite required. Since only 65% of the hypochlorite is chlorine, more than 120 lbs/day will be required:

$$\frac{120\ \text{lbs/day}\ Cl_2}{\frac{65\ \text{Avail.}\ Cl_2}{100}} = \boxed{\begin{array}{l}185\ \text{lbs/day}\\ \text{Hypochlorite}\end{array}}$$

Example 10: (Chemical Dosage)

❑ A wastewater flow of 850,000 gpd requires a chlorine dose of 25 mg/*L*. If sodium hypochlorite (15% available chlorine) is to be used, how many lbs/day of sodium hypochlorite are required? How many gal/day of sodium hypochlorite is this?

First, calculate the lbs/day chlorine required:

$$\underset{\text{Conc.}}{(\text{mg}/L)}\ \underset{\text{flow}}{(\text{MGD})}\ \underset{\text{lbs/gal}}{(8.34)} = \text{lbs/day}$$

$$(25\ \text{mg}/L)\ (0.85\ \text{MGD})\ (8.34\ \text{lbs/gal}) = \boxed{\begin{array}{l}177\ \text{lbs/day}\\ \text{Chlorine}\end{array}}$$

Then calculate the lbs/day sodium hypochlorite:

$$\frac{177\ \text{lbs/day}\ Cl_2}{\frac{15\ \text{Avail.}\ Cl_2}{100}} = \boxed{\begin{array}{l}1180\ \text{lbs/day}\\ \text{Hypochlorite}\end{array}}$$

Then calculate the gal/day sodium hypochlorite:

$$\frac{1180\ \text{lbs/day}}{8.34\ \text{lbs/gal}} = \boxed{\begin{array}{l}141\ \text{gal/day}\\ \text{Sodium Hypochlorite}\end{array}}$$

3.2 LOADING CALCULATIONS—BOD, COD AND SS

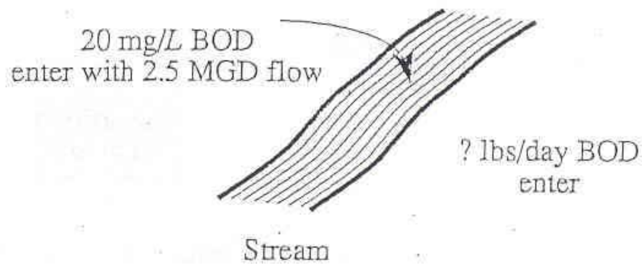
When calculating BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), or SS (Suspended Solids) loading on a treatment system, the following equation is used:

(mg/*L*)	(MGD)	(8.34)	= lbs/day
Conc.	flow	lbs/gal	

Loading on a system is usually calculated as lbs/day. Given the BOD, COD, or SS concentration and flow information, the lbs/day loading may be calculated as demonstrated in Examples 1-3.

Example 1: (Loading Calculations)

❑ Calculate the BOD loading (lbs/day) on a stream if the secondary effluent flow is 2.5 MGD and the BOD of the secondary effluent is 20 mg/*L*.



First, select the appropriate equation:

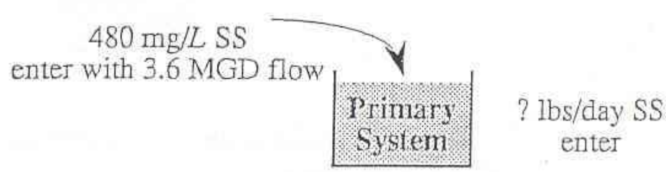
(mg/*L*) (MGD flow) (8.34 lbs/gal) = lbs/day

Then fill in the information given in the problem:

(20 mg/*L*) (2.5 MGD) (8.34 lbs/gal) = **417 lbs/day BOD**

Example 2: (Loading Calculations)

❑ The suspended solids concentration of the wastewater entering the primary system is 480 mg/*L*. If the plant flow is 3,600,000 gpd, how many lbs/day suspended solids enter the primary system?



First write the equation:

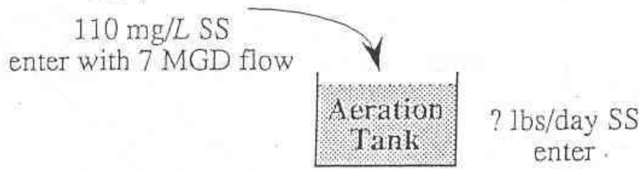
(mg/L) (MGD flow) (8.34 lbs/gal) = lbs/day

Then fill in the data given in the problem:

(480 mg/L) (3.6 MGD) (8.34 lbs/gal) = **14,412 lbs/day SS**

Example 3: (Loading Calculations)

- ❑ The flow to an aeration tank is 7 MGD. If the COD concentration of the water is 110 mg/L, how many pounds of COD are applied to the aeration tank daily?



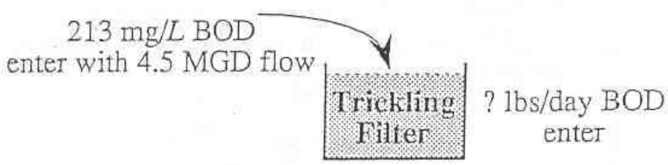
Use the mg/L to lbs/day equation to solve the problem:

(mg/L) (MGD flow) (8.34 lbs/gal) = lbs/day

(110 mg/L COD) (7 MGD) (8.34 lbs/gal) = $\boxed{\text{6422 lbs/day COD}}$

Example 4: (Loading Calculations)

- ❑ The daily flow to a trickling filter is 4,500,000 gpd. If the BOD concentration of the trickling filter influent is 213 mg/L, how many lbs BOD enter the trickling filter daily?



Write the equation, fill in the given information, then solve for the unknown value:

(mg/L) (MGD flow) (8.34 lbs/gal) = lbs/day

(213 mg/L) (4.5 MGD) (8.34 lbs/gal) = $\boxed{\text{7994 lbs/day BOD}}$

4.6 WEIR OVERFLOW RATE CALCULATIONS

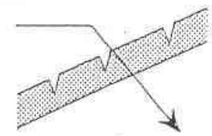
Weir overflow rate is a measure of the gallons per day flowing over each foot of weir.

$$\text{Weir Overflow Rate} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

Example 1: (Weir Overflow Rate)

❑ A rectangular clarifier has a total of 100 ft of weir. What is the weir overflow rate in gpd/ft when the flow is 1.2 MGD?

1,200,000 gpd



100 ft weir

$$\text{Weir Overflow Rate} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

$$= \frac{1{,}200{,}000 \text{ gpd}}{100 \text{ ft}}$$

$$= \boxed{12{,}000 \text{ gpd/ft}}$$

CALCULATING WEIR CIRCUMFERENCE

In some calculations of weir overflow rate, you will have to calculate the total weir length given the weir diameter. To calculate the length of weir around the clarifier, you need to know the relationship between the diameter and circumference of a circle. **The distance around any circle (circumference) is about three times the distance across the circle (diameter).** In fact, the circumference is (3.14) (Diameter).* Therefore, given a diameter, the total ft of weir can be calculated as:

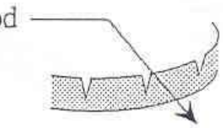
$$\text{Weir Length, ft} = (3.14)\ (\text{Weir Diam., ft})$$

Example 2: (Weir Overflow Rate)

❑ A circular clarifier receives a flow of 3.38 MGD. If the diameter of the weir is 80 ft, what is the weir overflow rate in gpd/ft?

The total ft of weir is not given directly in this problem. However, weir diameter is given (80 ft) and from that information we can determine the length of the weir.

3,380,000 gpd



ft weir:
$= (3.14)\ (80 \text{ ft})$
$= 251 \text{ ft}$

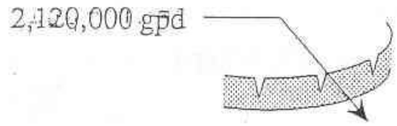
$$\text{Weir Overflow Rate} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

$$= \frac{3{,}380{,}000 \text{ gpd}}{251 \text{ ft}}$$

$$= \boxed{13{,}466 \text{ gpd/ft}}$$

Example 3: (Weir Overflow Rate)

❑ The flow to a circular clarifier is 2.12 MGD. If the diameter of the weir is 60 ft, what is the weir overflow rate in gpd/ft?



ft weir:

$= (3.14)\ (60\ \text{ft})$

$= 188\ \text{ft}$

$$\text{Weir Overflow Rate} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

$$= \frac{2{,}120{,}000\ \text{gpd}}{188\ \text{ft}}$$

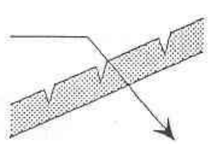
$$= \boxed{11{,}277\ \text{gpd/ft}}$$

Example 4: (Weir Overflow Rate)

❑ A rectangular sedimentation basin has a total weir length of 80 ft. If the flow to the basin is 1.3 MGD, what is the weir loading rate in gpm/ft?

$$\frac{1{,}300{,}000\ \text{gpd}}{1440\ \text{min/day}}$$

$= 903\ \text{gpm}$



$$\text{Weir Loading Rate} = \frac{\text{Flow, gpm}}{\text{Weir Length, ft}}$$

$$= \frac{903\ \text{gpm}}{80\ \text{ft weir}}$$

$$= \boxed{11.3\ \text{gpm/ft}}$$

WEIR LOADING RATE

Weir overflow rate is a term most often associated with wastewater clarifier calculations. A similar calculation often used for water system clarifiers is weir loading rate, expressed as gpm/ft.

5.1 DETENTION TIME CALCULATIONS

There are two basic ways to consider detention time:

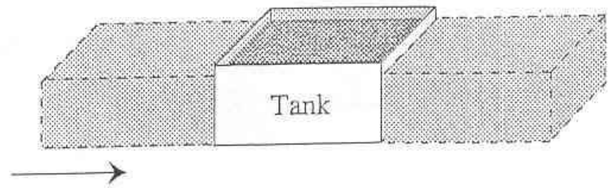
1. Detention time is the length of time required for a given flow rate to pass through a tank.
2. Detention time may also be considered as the length of time required to fill a tank at a given flow rate.

In each case, the calculation of detention time is the same:

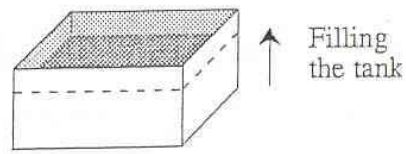
$$\text{Detention Time} = \frac{\text{Volume of Tank, gal}}{\text{Flow Rate, gal/time}}$$

THE TWO FACES OF DETENTION TIME

Flow-Through Time:



Fill Time:



MATCHING UNITS

There are many possible ways of writing the detention time equation, depending on the time unit desired (seconds, minutes, hours, days) and the expression of volume and flow rate.

When calculating detention time, it is essential that the time and volume units used in the equation are consistent with each other, as illustrated to the right.

BE SURE THE TIME AND VOLUME UNITS MATCH

$$\underset{\text{min}}{\text{Detention Time}} = \frac{\text{Volume of Tank, gal}}{\text{Flow Rate, gpm}}$$

Time units match (min)

Volume units match (gal)

Other examples of detention time equations where time and volume units match include:

$$\text{Detention Time, sec} = \frac{\text{Volume of Tank, cu ft}}{\text{Flow Rate, cfs}}$$

$$\text{Detention Time, hrs} = \frac{\text{Volume of Tank, gal}}{\text{Flow Rate, gph}}$$

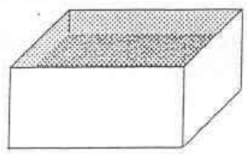
$$\text{Detention Time, days} = \frac{\text{Volume of Pond, ac-ft}}{\text{Flow Rate, ac-ft/day}}$$

Example 1: (Detention Time)

❑ The flow to a sedimentation tank 80 ft long, 30 ft wide and 10 ft deep is 3.7 MGD. What is the detention time in the tank in hours?

$$(80\text{ ft})\,(30\text{ ft})\,(10\text{ ft})\,(7.48\text{ gal/cu ft}) = \underset{\text{Volume}}{179{,}520\text{ gal}}$$

$$\frac{3{,}700{,}000\text{ gpd}}{24\text{ hrs/day}} = 154{,}167\text{ gph}$$



First, write the equation so that volume and time units match. Then fill in the equation and solve for the unknown.

$$\underset{\text{hrs}}{\text{Detention Time}} = \frac{\text{Volume of Tank, gal}}{\text{Flow Rate, gph}}$$

$$= \frac{179{,}520\text{ gal Volume}}{154{,}167\text{ gph}}$$

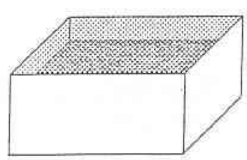
$$= \boxed{1.2\text{ hours}}$$

Example 2: (Detention Time)

❑ A flocculation basin is 8 ft deep, 15 ft wide, and 40 ft long. If the flow through the basin is 2.2 MGD, what is the detention time in minutes?

$$(40\text{ ft})\,(15\text{ ft})\,(8\text{ ft})\,(7.48\text{ gal/cu ft}) = \underset{\text{Volume}}{35{,}904\text{ gal}}$$

$$\frac{2{,}200{,}000\text{ gpd}}{1440\text{ min/day}} = 1528\text{ gpm}$$



$$\underset{\text{min}}{\text{Detention Time}} = \frac{\text{Volume of Tank, gal}}{\text{Flow Rate, gpm}}$$

$$= \frac{35{,}904\text{ gal Volume}}{1528\text{ gpm}}$$

$$= \boxed{23\text{ minutes}}$$

DETENTION TIME AS FLOW THROUGH A TANK

In calculating unit process detention times, you are calculating the length of time it takes the water to flow through that unit process. Detention times are normally calculated for the following basins or tanks:

- Flash mix chambers (sec)
- Flocculation basins (min)
- Sedimentation tanks or clarifiers (hrs),
- Wastewater ponds (days),
- Oxidation ditches (hrs).

There are two key points to remember when calculating detention time:

1. **Tank volume is the numerator (top) of the fraction** and flow rate is the denominator (bottom) of the fraction. Many times students have a difficult time remembering which term belongs in the numerator and which in the denominator. As a memory aid, remember that "V," the victor, is always on top.

2. **Time and volume units must match.** If detention time is desired in minutes, then the flow rate used in the calculation should have the same time frame (cfm or gpm, depending on whether tank volume is expressed as cubic feet or gallons). If detention time is desired in hours, then the flow rate used in the calculation should be cfh or gph.

DETENTION TIME FOR PONDS

Detention time for a pond may be calculated using one of two equations, depending on how the flow rate is expressed:

$$\text{Detention Time, days} = \frac{\text{Pond Volume, gal}}{\text{Flow Rate, gpd}}$$

Or

$$\text{Detention Time, days} = \frac{\text{Pond Volume, ac-ft}}{\text{Flow Rate, ac-ft/day}}$$

For a better understanding of the relative sizes of MGD and ac-ft/day, remember that 1 MGD is equivalent to about 3 ac-ft/day flow.

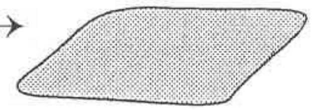
Examples 3 and 4 illustrate the use of both detention time equations.

Example 3: (Detention Time)

❑ A waste treatment pond is operated at a depth of 5 feet. The average width of the pond is 375 ft and the average length is 610 ft. If the flow to the pond is 570,000 gpd, what is the detention time in days?

$$(610\text{ ft})\ (375\text{ ft})\ (5\text{ ft})\ (7.48\text{ gal/cu ft}) = 8{,}555{,}250\text{ gal Volume}$$

570,000 gpd ⟶



$$\text{Detention Time, days} = \frac{\text{Volume of Pond, gal}}{\text{Flow Rate, gpd}}$$

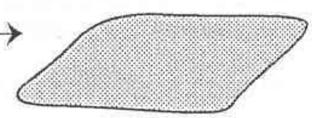
$$= \frac{8{,}555{,}250\text{ gal Volume}}{570{,}000\text{ gpd}}$$

$$= \boxed{15\text{ days}}$$

Example 4: (Detention Time)

❑ A waste treatment pond is operated at a depth of 6 feet. The volume of the pond is 54 ac-ft. If the flow to the pond is 2.7 ac-ft/day, what is the detention time in days?

2.7 ac-ft/day ⟶



$$\text{Detention Time, days} = \frac{\text{Volume of Pond, ac-ft}}{\text{Flow Rate, ac-ft/day}}$$

$$= \frac{54\text{ ac-ft Volume}}{2.7\text{ ac-ft/day}}$$

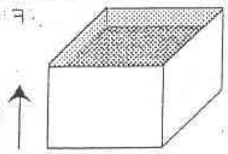
$$= \boxed{20\text{ days}}$$

Example 5: (Detention Time)

❑ A basin 4 ft square is to be filled to the 3 ft level. If the flow to the tank is 3 gpm, how long will it take to fill the tank (in hours)?

(4 ft) (4 ft) (3 ft) (7.48 gal/cu ft) = 359 gal Volume

(3 gpm) (60 min/hr) = 180 gph



$$\text{Fill Time, hrs} = \frac{\text{Volume of Tank, gal}}{\text{Flow Rate, gph}}$$

$$= \frac{359 \text{ gal Volume}}{180 \text{ gph}}$$

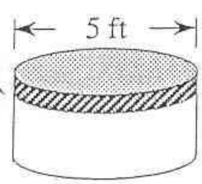
$$= \boxed{2 \text{ hrs}}$$

Example 6: (Detention Time)

❑ A tank has a diameter of 5 ft with an overflow depth at 4 ft. The current water level is 2.8 ft. Water is flowing into the tank at a rate of 4.1 gpm. At this rate, how long will it take before the tank overflows (in min)?

The volume of the tank remaining to be filled is 5 ft in diameter and 1.2 ft deep (4 ft – 2.8 ft = 1.2 ft). Therefore, the fill volume is:

(0.785) (5 ft) (5 ft) (1.2 ft) (7.48 gal/cu ft) = 176 gal Vol.



$$\text{Time Until Overflow, min} = \frac{\text{Volume of Tank, gal}}{\text{Flow Rate, gpm}}$$

$$= \frac{176 \text{ gal Volume}}{4.1 \text{ gpm}}$$

$$= \boxed{43 \text{ min until overflow}}$$

DETENTION TIME AS FILL TIME

Another way to think of detention time is the time required to fill a tank or basin at a given flow rate. Regardless of whether you consider detention time flow time through a tank, or fill time, the calculation is precisely the same:

$$\text{Detention Time} = \frac{\text{Volume of Tank, gal}}{\text{Flow Rate, gal/time}}$$

In some equations, the word *fill time* is used rather than detention time.

$$\text{Fill Time} = \frac{\text{Volume of Tank, gal}}{\text{Flow Rate, gal/time}}$$

In each equation listed above the volume can be given as cubic feet, if desired (cu ft and cu ft/time).

The fill time calculation can also be used to determine the **time remaining before a tank overflows**, as illustrated in Example 6. Such a calculation can be critical during equipment failure conditions.

18.1 BIOCHEMICAL OXYGEN DEMAND (BOD) CALCULATIONS

The Biochemical Oxygen Demand (BOD) content of a wastewater is used as an indicator of the available food in the wastewater, and is therefore included in such calculations as organic loading and F/M ratio.

The BOD test measures the amount of oxygen used by the microorganisms as they breakdown food (complex organic compounds) in the wastewater.

The dissolved oxygen (DO) content of the sample is tested just prior to beginning the test (initial DO) and at the end of the test. Then by subtracting the second DO reading from the initial DO, **the amount of DO used during the test can be determined:**

$$\text{Initial DO, mg}/L - \text{DO After 5-day Test, mg}/L = \text{DO Used During, mg}/L$$

If the BOD test were conducted using a full-strength sample, the BOD content (mg/L) would be equal to the dissolved oxygen (DO) used or depleted during the 5-day test. For example, if the DO used during the 5-day BOD test was 75 mg/L, then the BOD would be the same—75 mg/L.

However, **the BOD test is conducted on a diluted sample.** Therefore, the percent dilution of the sample must be included in the calculation, as shown in the equations to the right.*

Depending on the percent dilution, the DO used in the diluted sample might represent only 1% to 10% of the DO used in the full-strength sample.

THE BOD TEST IS CONDUCTED ON A DILUTED SAMPLE

Simplified Equation:

$$\text{BOD mg}/L = \frac{\text{DO Used During 5-day Test, mg}/L}{\text{Dilution Fraction of Sample}}$$

Or

Expanded Equation:

$$\text{BOD mg}/L = \frac{\text{Initial DO, mg}/L - \text{DO After 5 days, mg}/L}{\dfrac{\text{Sample Volume, m}L}{\text{BOD Bottle Volume, m}L}}$$

Example 1: (BOD)

❑ Given the following information, determine the BOD of the wastewater:

Sample Volume—4 mL
BOD Bottle Volume—300 mL
Initial DO of Diluted Sample—7 mg/L
DO of Diluted Sample—4 mg/L (After 5 days)

7 mg/L DO (Initial) → 5-day Test → 4 mg/L DO (After 5-days)
↓
3 mg/L DO Used in 5 days

$$\text{BOD mg}/L = \frac{\text{Initial DO, mg}/L - \text{DO After 5-days, mg}/L}{\dfrac{\text{Sample Volume, m}L}{\text{BOD Bottle Volume, m}L}}$$

$$= \frac{7\text{ mg}/L - 4\text{ mg}/L}{\dfrac{4\text{ m}L}{300\text{ m}L}}$$

$$= \frac{3\text{ mg}/L}{0.013}$$

$$= \boxed{231\text{ mg}/L\text{ BOD}}$$

Example 2: (BOD)

❑ Results from a BOD test are given below. Calculate the BOD of the sample.

Sample Volume—30 mL
BOD Bottle Volume—300 mL
Initial DO of Diluted Sample—8 mg/L
DO of Diluted Sample—3.7 mg/L (After 5 days)

8 mg/L DO (Initial) → 5-day Test → 3.7 mg/L DO (After 5-days)

↓

4.3 mg/L DO
Used in 5 days

$$\text{BOD, mg/}L = \frac{\text{Initial DO, mg/}L - \text{DO After 5 days, mg/}L}{\text{Dilution Fraction of Sample}}$$

$$= \frac{8 \text{ mg/}L - 3.7 \text{ mg/}L}{0.1}$$

$$= \boxed{43 \text{ mg/}L \text{ BOD}}$$

Example 3: (BOD)

❑ Given the information listed below, determine the BOD of the wastewater.

Sample Volume—7 mL
BOD Bottle Volume—300 mL
Initial DO of Diluted Sample—9 mg/L
DO of Diluted Sample—3.2 mg/L (After 5 days)

9 mg/L DO (Initial) → 5-day Test → 3.2 mg/L DO (After 5-days)

↓

5.8 mg/L DO
Used in 5 days

$$\text{BOD, mg/}L = \frac{\text{Initial DO, mg/}L - \text{DO After 5 days, mg/}L}{\text{Dilution Fraction of Sample}}$$

$$= \frac{9 \text{ mg/}L - 3.2 \text{ mg/}L}{0.023}$$

$$= \boxed{252 \text{ mg/}L \text{ BOD}}$$

Disinfecting a Cistern

A cistern that is 12 feet long and four feet wide with a water depth of four feet is to be disinfected with sodium hypochlorite. Given: *1 gallon of sodium hypochlorite will disinfect 50,000 gallons of water*. How much ounces of sodium hypochlorite will be needed to disinfect the water in the cistern?

Answer:

12 feet x 4 feet x 4 feet = 576 cubic feet

Cubic feet is converted to gallons by utilizing the conversion constant 7.48

576 x 7.48 = 4308.48 gallons

If 1 gallon of sodium hypochlorite will disinfect 50,000 gallons of water, how much is needed to disinfect 4308.48 gallons?

4308.48 ÷ 50,000 = 0.081 gallons

To convert to fluid ounces, know that there are 128 fluid ounces in a gallon

0.081 x 128 = 11.08 fluid ounces (round off to 11 fluid ounces)